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SUPPLEMENT TO DEVELOPMENT DOCUMENT: HAZARDOUS SUBSTANCES REGULATIONS, SECTION 311 OF THE FEDERAL WATER POLLUTION CONTROL ACT AS AMENDED 1972

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This is a compilation of documents relating to chemicals proposed as hazardous substances under Section 311 of the Federal Water Pollution Control Act of 1972. These chemical profiles represent the bulk of the data utilized in determining which substances were placed on the initial listing of substances. Each profile deals with a substance under consideration either as a unique compound or as the parent ion of various salt forms. Each one consists of a data sheet which presents the physical, chemical, and toxicological data as well as information concerning its manufacture, handling and shipment. In addition, a narrative summary providing a limited interpretation of the data is presented, but is not an analysis of the data in a scientific sense. These data are published in this form for use, along with previously published selection criteria to assist interested persons in understanding the overall approach used in selecting the listed materials.

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SUPPLEMENT TO DEVELOPMENT DOCUMENT

HAZARDOUS SUBSTANCES REGULATIONS
SECTION 311 OF THE FEDERAL WATER POLLUTION CONTROL ACT AS AMENDED 1972

by

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WASHINGTON, D. C. 20460

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INTRODUCTION

This is a compilation of documents relating to chemicals proposed as hazardous substances (40 CFR Part 116) under Section 311 of the Federal Water Pollution Control Act of 1972. These chemical profiles represent the bulk of the data utilized in determining which substances were placed on the initial listing of substances. Each profile deals with a substance under consideration either as a unique compound or as the parent ion of various salt forms. Each one consists of a data sheet which presents the physical, chemical, and toxicological data as well as information concerning its manufacture, handling and shipment. In addition, a narrative summary providing a limited interpretation of the data is presented, but is not an analysis of the data in a scientific sense. No attempt has been made to standardize or abridge any of the data other than to present it in a consistent form for ease of understanding and comparison. These data are published in this form for use, along with previously published selection criteria (40 CFR Part 116), to assist interested persons in understanding the overall approach used in selecting the listed materials.

The data on each substance have been collected from a variety of sources, including extensive primary literature surveys and compendia such as; the HEW Toxic Substance List, the National Academy of Sciences Water Quality Criteria, and the Water Quality Criteria Data Book, Vol. 3.

The sole purpose of assembling the data has been to provide a technical basis to meet the regulation requirements under Section 311. These data should not be confused with information collected for other purposes nor should they be viewed as valid for alternative uses. Although the Agency has attempted to include all available information, there is no attempt to represent the data as complete or final. Additions and corrections to the data are encouraged and may be achieved by contacting Hazardous Substances Branch, WH-595, Office of Water Planning and Standards, Environmental Protection Agency, Washington, D.C. 20460 (202) 245-3039.

KEY TO DATA SHEETS

Name - The most frequently used common name of the chemical.

Production Quantity - The reported or estimated annual production of the chemical, and the year for which the cited figure was reported.

Synonyms - Alternative common names.

Common Ship or Container Size - Information on handling and shipping.

DOT - Summarization of Department of Transportation regulatory requirements for labeling and shipment.

USCG - Coast Guard classification for vessel transport.

M.P. - Melting point of the substance.

B.P. - Boiling point at standard pressure unless otherwise noted.

Sp.G. - Specific gravity of the chemical (water = 1.0)

Solubility - Solubility properties in water.

Persistence -

Oxygen Demand - Biochemical Oxygen Demand (BOD) is given in either pounds of oxygen per pound of chemical or percent of theoretical demand. Subscripted numbers indicate the duration of the test in days and experimental conditions are given. Chemical Oxygen Demand (COD) is given in pounds of oxygen per pound of chemical using standard test procedures unless otherwise noted.

Chemical Hydrolysis - Describe hydrolysis or auto-degradation characteristics and products.

Toxicological -

Aquatic Toxicity -

ppm - Concentration in parts per million, by weight, of the test chemical in water.

hrs - Duration of the bioassay in hours.

species - The test species (generally the common name).

parm - The test parameter or end point of the bioassay.

cond - Any stated test conditions such as temperature, hardness, dissolved oxygen, etc.

Mammalian Toxicity -

species - Common name of the test organism.

mg/kg B.W. - The test dosage in milligrams of toxicant per kilogram of body weight of the test animals.

administration route - Method of exposure of test animals to the toxicant.

References - In the toxicity tables, references are presented under the column labeled "ref". All other references are in parenthesis.

ACETALDEHYDE

Acetaldehyde is used in the production of such diversified products as flavors and perfume, plastics, dyes and synthetic rubber. The 130 x 10^6 lbs produced in the United States in 1970 were shipped in a variety of containers ranging from on quart glass bottles to tank barges.

Acetaldehyde can creat a significant oxygen demand in water with which it is miscible. Bacterial cultures acclimate to aqueous solutions rapidly, degrading from 40 to 93 percent in a five day period (4,5). Oxygen slumps are likely to accompany spills of acetaldehyde. Massive doses, however, can suppress oxygen utilization through toxic action on bacterial life. Concentrations of 230 mg/l have been found to suppress oxygen uptake of synthetic sewage 50 percent (6). In addition to biochemical oxygenation, acetaldehyde will undergo chemical oxygenation to become acetic acid as a result of prolonged contact with air (6). The product acetic acid is also highly degradable with biological action.

Although a great deal of fresh water toxicological data does not exist, McKee and Wolf(1) note a 96 hour TLm for sunfish in soft water of 53 ppm. Levels of 249 ppm can kill half the diatom population in soft water(1). When exposed for 96 hours, fathead minnows were all killed by a concentration of 70 ppm, but showed no toxic effects in 60 ppm(426).

Salt water toxicity evaluations with pin perch indicate a 24 hour threshold of 70 ppm, with 60 ppm showing no kill(1). Shrimp in an aerated tank registered a 48 hr LC50 at >100 ppm.

Oral administration of 1900 mg/Kg body weight proved to be the LD50 for rats(3).

Additional aqueous concentrations of interest include a median odor threshold of 2.1 ppm(7) and a recommended prolonged human contact limit of 1100 ppm(7).

NAME Acetaldehyde

PRODUCTION QUANTITY 1.6 billion lbs, 1971 (199)

SYNONYMS Ethanal, Aceticaldehyde, Ethylaldehyde

COMMON SHIP G. CONTAINER SIZE one quart bottles, 5-55 gal drums,
insulated tank cars and insulated
tank trucks, tank barges

DOT Flammable Liquid, red label, 10 gal outside container

USCG Grade A flammable liquid

M.P. -123.5 °C

B.P. 20.8 °C

Sp. G. 0.783

SOLUBILITY Miscible

PERSISTENCE

Oxygen Demand
BOD_5 = 1.27 lb/lb-Sewage Seed-(4)
BOD_5 = 93% Theo.-Activated Sludge in quiescent conditions-(5)
BOD_1 = 49% Theo.-Seed acclimated to ethanol in treatment plant-(5)
BOD_5 = 40% Theo.-Pure bacterial culture-(5)

Chemical Hydrolysis, etc.

Degrades to acetic acid with prolonged exposure to air

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
53	96	Sunfish	TLm	Soft water at 18-20°C	1
249		Diatom	50% Kill	Soft water at 18-20°C	1
>100	72	Fathead Minnow	100% Kill	50°F, Huron	426
100	72	Fathead Minnow	Partial Kill	50°F, Huron	426
80	72	Fathead Minnow	No Toxic Effect	50°F, Huron	426
70	96	Fathead Minnow	100% Kill	50°F, Huron	426
60	96	Fathead Minnow	No Toxic Effect	50°F, Huron	426
100	72	Shiners	100% Kill	50°F, Huron	426
80	72	Shiners	Partial Kill	50°F, Huron	426
70	72	Shiners	No Toxic Effect	50°F, Huron	26

Salt Water Toxicity

70	24	Pin Perch	TLm		1
60	24	Pin Perch	No Kill		1
>100	48	Shrimp	LC50	Aerated	2

Mammalian

species	mg/kg b.w.	administration route	ref
Rat	1900	Oral	1

ACETIC ACID

Acetic acid is employed by a variety of industries for the production of acetate esters. The 2,050,000,000 lbs produced in 1971 were shipped in glass carboys, 5, 10 & 55 gallon metal drums, wooden barrels, and aluminum tank cars. Acetic acid is shipped in large quantities across the nation.

Acetic acid in dilute concentrations will be neutralized by natural waters to acetate salts. Stronger concentrations will be subject to biochemical degradation. Acetic acid, which is miscible in water, may produce oxygen demands of .34-.88 lb/lb of acid during a five day period (4). This represents up to 83% of the theoretical demand. Chemical oxygen demand may reach 1.0 lb/lb of acid (4). High concentrations of acetic acid are capable of producing pH's which are toxic to oxidizing bacteria and hence can inhibit oxygen demand (6). Oxygen deficiencies may well occur when acetic acid is spilled as a result of both rapid biochemical and chemical oxygen utilization.

Acetic acid is toxic to various game and sport fishes in the 75-100 ppm range (1). Water pH and alkalinity can have a marked effect on toxicity, since acetic acid may kill aquatic organisms via inherent toxicity or intolerable pH levels. Concentrations of 150 ppm were found to be toxic to Chlorella pyrenoidosa (4) while 74 ppm in soft water is sufficient to cause a 50% reduction in growth of the diatom Navicula seminulum (1). Threshold for immobilization of Daphnia in Lake Erie was found to be 80-150 ppm (1). Hardness has been shown to be antagonistic to fresh water toxicity, raising the threshold concentration for given TLm values (1).

Median lethal doses for oral administration to rats and mice have been reported as 1310 mg/Kg and 4060 mg/Kg body weight respectively (1). In general, mammals record oral LD 50's in the range 2500-5000 mg/Kg body weight. In addition to inherent toxicity, concentrated solutions can cause damage through corrosive acid action.

Other aquatic concentrations of interest include odor thresholds in the range 5-80 ppm and taste thresholds in the range 300-1000 ppm (7).

NAME Acetic Acid

PRODUCTION QUANTITY 2,050,000,000 lbs 1971 (198)

SYNONYMS Ethanoic Acid, Glacial Acetic Acid

COMMON SHIP OR CONTAINER SIZE glass carboys, 5, 10 & 55 gal metal drums, wooden barrels, and aluminum tank cars

USCG Grade D combustible liquid

M.P. 16.6 °C

B.P. 118.1 °C

Sp.G. 1.049

SOLUBILITY Miscible in hot or cold water

PERSISTENCE

Oxygen Demand

BOD_5 = 80% Theo. with Phenol acclimated activated sludge-(11)
BOD_5 = .34-.88 lb/lb using sewage seed-(4,15)
BOD_5 = 53% Theo. using activated sludge in a respirometer-(10)
BOD_{20}= .9 lb/lb-(14)
COD = 1 lb/lb-(4)
$BOD_{5,10,15,20}$ = 76,82,85,96% Theo. in freshwater-(425)
$BOD_{5,10,15,20}$ = 66,80,88,100% Theo. in saltwater-(425)

Chemical Hydrolysis, etc.

Natural waters will neutralize dilute solutions to acetate salts.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resm	cond	ref
75	96	Bluegill	TLm		6
50	24	Brook Trout	Lethal		[illegible]
114	24	Minnow	Lethal		[illegible]
100-200	96	Creek Chub	TLm		5
423	24	Goldfish	MLD		[illegible]
75	96	Sunfish	TLm	18-20°C Soft Water	[illegible]
378	72	Channel Catfish	TLm	25°C	[illegible]
251	24,48,96	Mosquito Fish	TLm	Turbid	[illegible]
520	72	Channel Catfish	100%K	25°	[illegible]

100	96	Goldfish	TLm		15
150		Chlorella Pyrenoidosa	Toxic		4
74	Chronic	Aquatic Plants	Toxic		1
>100	72	Fathead Minnow	No Toxic Effect	50°F, Huron	426

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
100-300	48	Shrimp	LC50	Aerated	2
42	24	Brine Shrimp	TLm		425
32	48	Brine Shrimp	TLm		425

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	3310	Oral	1
Mice	4960	Oral	1
Mammals	2500-5000	Oral	15

ACETIC ANHYDRIDE

Acetic anhydride, like its hydrated sister acetic acid, is used largely as an intermediate for the production of cellulose acetates and esters. The 1,550,000,000 lbs produced in 1971 were shipped in one gallon glass jugs; carboys of up to 13 gallon capacity; 5, 10, and 55 gallon stainless steel drums; aluminum tank cars; and tank barges.

Acetic anhydride hydrolyses to acetic acid upon contact with water. An LD50 of 1780 mg/Kg body weight was obtained when acetic anhydride was administered orally to rats (8). Because of rapid hydrolysis to the acid form, the anhydride can be very corrosive to tissues when ingested.

Aquatic toxicity and concentrations of interest are identical to those of acetic acid, since the anhydride does not exist in solution.

NAME Acetic Anhydride

PRODUCTION QUANTITY 1,550,000,000 lb 1971 (199)

SYNONYMS Ethanoic Anhydride, Acetyl Oxide, Acetic Acid Anhydride

COMMON SHIP OR CONTAINER SIZE one gallon jugs, 13 gal carboys,
5,10, 55 gal drums, tank cars,
tank barges

USCG Grade D combustible liquid

M.P. -73.1 °C

B.P. 140 °C

Sp.G. 1.083

SOLUBILITY 120,000 ppm at 25°C

PERSISTENCE

Oxygen Demand

Same as that for acetic acid

Chemical Hydrolysis, etc.

Hydrolyses to acetic acid on contact with water.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to acetic acid-Toxicity is 1.72 times less on weight basis.

Salt Water Toxicity

Refer to acetic acid-Toxicity is 1.72 times less on weight basis.

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	1780	Oral	8

ACETONE CYANOHYDRIN

Acetone cyanohydrin finds service as an intermediate in the production of various organic materials such as α-hydroxy acids and acrylonitriles. The 1,380 million pounds produced in 1970 were largely shipped in carboys, drums, and tank barges. Transportation spills have occurred from tank cars involved in train wrecks. Acetone cyanohydrin is made from HCN and acetone under alkaline conditions. It is then made and kept acidic with sulfuric acid. The composition by weight is as follows: 98% acetone, .15% HCN, .8% acetone, .4% water and .5% stabilizer and inert material. It is treated as HCN for safety precautions in industries.

Acetone cyanohydrin persisting mainly as acetone cyanohydrin may decompose slowly to form hydrogen cyanide and acetone (8). HCN concentrations of 10 ppm may be exceeded. pH would not be a major factor in the toxicity of this compound. The potential release of cyanide, however, will suppress bacterial action on concentrated solutions of the parent cyanohydrin. Though highly soluble, oxygen demand problems are not expected to be of major concern with acute spills.

Median lethal doses from oral administration range from 8-40 mg/kg body weight for mammals (15). Direct ingestion limits reflect the presence of toxic hydrogen cyanide. Greater absolute amounts may well be tolerable when administered in water. Chronic threshold levels for oral administration to rats over a six month period were found to be .0005 mg/kg body weight/day (15).

NAME - Acetone Cyanohydrin

PRODUCTION QUANTITY - 1,380 million lbs 1970 (105)

SYNONYMS - a-Hydroxy Isobutyronitrile, Acetone Cyanohydrin,
Isopropyl Cyanohydrin, 2-Hydroxy-2 methylpropanenitrile

COMMON SHIP OR CONTAINER SIZE - carboys, drums, tank barges

DOT - Class B poison, poison label 55 gal outside container

USCG - Grade E combustible liquid - class B poison

M.P. -19.0°C

B.P. - 120.0°C decomposes

Sp.G. - 0.932

SOLUBILITY - Very soluble in hot and cold water

PERSISTENCE

Chemical Hydrolysis, etc.

May slowly decompose to form hydrogen cyanide

TOXICOLOGICAL

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	13.3	Oral	15
Guinea Pig	9.0	Oral	15
Mouse	2.9	Oral	15
Rabbit	13.5	Oral	15

ACETYL BROMIDE

Acetyl bromide can be employed as an acetylating or brominating agent. It is presently marketed by five major producers.

Acetyl bromide like all acetyl halides decomposes violently in water or alcohol, hydrolyzing to form hydrogen bromide and acetic acid. While the acetic acid fraction is highly susceptible to biological action, at higher concentrations the hydrobromic acid will inhibit the bacteria. The double acid product will also reduce pH much more rapidly than straight acetic acid.

Aquatic toxicity will be that noted for the individual hydrolysis products. It should be noted, however, that the resulting acidity will rapidly drop pH below the 6.8 level at which acetic acid is toxic under normal conditions. Direct ingestion of acetyl halides is very hazardous as a result of the immediate corrosive action of the agent on the mouth and rapid reaction with the -NH groups associated with protein molecules.

NAME Acetyl Bromide

M.P. -96.0 °C

B.P. 81.0 °C

Sp.G. 1.520

SOLUBILITY Decomposes in water

PERSISTENCE

Chemicaly Hydrolysis, etc.

Violently decomposes in water to release hydrogen bromide and acetic acid.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to hydrogen bromide and acetic acid. H Br is the controlling factor.

Salt Water Toxicity

Refer to hydrogen bromide and acetic acid. H Br is the controlling factor.

ACETYL CHLORIDE

Acetyl chloride, an acetylating agent, is presently produced by three major firms.

Like all acetyl halides, the chloride derivative decomposes violently when contacted with water or alcohol. Acetic acid and hydrogen chloride constitute the two major hydrolysis products. While the acetic acid is biodegradable, the presence of hydrogen chloride can inhibit bacterial action.

Aquatic toxicity will be that for acetic acid and hydrogen chloride. The two products will both contribute to acidity and hence will have additive effects. Direct ingestion of acetyl halides is very hazardous both because of the immediate corrosive damage to tissues in the mouth, and because of the toxic effect due to reaction with -SH groups on protein molecules.

NAME Acetyl Chloride

DOT Corrosive Liquid, White Label

USCG White Label

M.P. -112.0 °C

B.P. 51.0 °C

Sp.G. 1.1051

SOLUBILITY Decomposes in water

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes in water to hydrogen chloride and acetic acid.

TOXICOLOGICAL

Fresh Water Toxicity

Toxicity will be that of the HCl hydrolysis product.

Salt Water Toxicity

Toxicity will be that of the HCl hydrolysis product.

ACROLEIN

Acrolein is used in a variety of applications including the production of plastics, organic chemicals, perfumes, and refrigerants; as an active agent in military chemical weapons; and as a biocide. The 55 million lbs of acrolein produced in 1969 were shipped in metal drums 1 to 55 gallons in capacity and in tank cars.

Acrolein, a soluble unsaturated aldehyde, is subject to slow biodegradation. Experimental evaluations resulted in consumption of 33 percent of the theoretical oxygen demand over 10 days in quiescent conditions (5) and 30 percent over 5 days when acclimated seed was employed. Biological actions, however, can only be expected at low concentration levels due to the biological activity of acrolein. Sewage organisms have undergone toxic reactions to concentrations of 1.5 ppm. Similarly, 10 ppm was toxic to acclimated sewage bacteria (25). Oxygen slumps are not likely to occur due to spills. While relatively stable in water, the unsaturated bond in acrolein is subject to photochemical attack over a period of time. Because of acrolein's reactivity, waters actually display an acrolein demand. These reactions are generally slow, however, and never approach the chlorine demand of the same water. In general, acrolein will dissipate slowly in time due solely to chemical reaction. Hydrogen or sodium sulfide can neutralize acrolein if present in the affected waters.

Acrolein is quite toxic to fish and other aquatic life. Concentrations as low as .08 ppm killed half of a test sample of salmon in 24 hours (15). Rainbow trout showed a similar response in 24 hours to .14 ppm (1). Concentrations of 3-15 ppm were sufficient to kill such wide ranging species as tadpoles, bluegills, walleyes, and snails. Toxic levels for aquatic plants center around 3 ppm (1). Acrolein displays acute toxicity to marine organisms as well. Concentrations in the .055-.24 ppm range had marked toxic effects on shellfish and longnose killifish (23). Increased organic content of waters will reduce acrolein's residency time and hence can reduce lethal exposure times.

Mammals experience acute LD50 when fed 7-46 mg/Kg body weight (1,15). Acrolein is considered to give good warning of its presence, however. It is physiologically detectable at 1 ppm (17) and causes lachrimation when contacted as a vapor. Ingestion results in acute irritation of tissues. Acrolein can be toxic if absorbed through the skin. Weekly applications of .5% solutions in acetone for 10 weeks resulted in 2/15 tumors in mice (15). Acrolein is also known to react with t-RNA (19).

NAME Acrolein

PRODUCTION QUANTITY 55 million lbs 1969 (198)

SYNONYMS 2-Propenal, Acrylic Aldehyde, Acrylaldehyde, Acraldehyde

COMMON SHIP OR CONTAINER SIZE Metal drums up to 55 gal, tank cars

DOT Flammable Liquid, Red Label, 1 quart outside container

M.P. -88.0 °C

B.P. 52.5 °C

Sp.G. 0.839

SOLUBILITY 400,000 ppm at 25°C

PERSISTENCE

Oxygen Demand

BOD_{10} = 33% Theo under quiescent conditions-(5)
BOD_5 = 30% Theo using acclimated seed-(24)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
1		Tadpole, Small Bluegills, & Walleye	Lethal	Pond	1
10	3	Snail Eggs	100% Kill		1
10	24	Adult Snails	90% Kill		1
.08	24	Salmon	TLm		15
.08	48	Salmon	LC50		20
100		Microlife	80-90% Kill	Standing Water	21
.14	24	Rainbow Trout	LC50		22
1	72	Fathead Minnow	100% Kill	50°F;Huron	426
0.75	72	Fathead Minnow	Partial Kill	50°F;Huron	426
0.2	72	Fathead Minnow	No Toxic Effect	50°F;Huron	426

Salt Water Toxicity

0.055	96	Oyster	EC50		23
0.24	48	Longnose Killifish	LC50	21°C	23
0.10	24	Brown Shrimp	LC50	28°C	23
.1	48	Brown Shrimp	LC50	25°C	23

Mammalian

species	mg/kg b. w.	administration route	ref.
Mice	30	Oral	15
Rat	46	Oral	1
Rabbit	7.1	Oral	1

ACRYLONITRILE

Acrylonitrile, the cyanide derivative of the vinyl monomer, is used in the production of nitrile rubbers and synthetic fibers. Lined pails, drums, tank cars, and tank trucks were used to ship the 1,600 million lbs produced in 1976. The expected growth rate for the next few years will average 8-10%/yr

Acrylonitrile is subject to spontaneous polymerization when left standing. In aqueous media the process is slower but can be initiated with persulfate, peroxide or concentrated alkali. Light accelerates polymerization while exposure to oxygen appears to inhibit it. Yellowing upon prolonged exposure to light indicates photodegradation to saturated derivatives. This compound does not appear to dissociate in water and consequently is not expected to release HCN(1). Acrylonitrile is subject to biodegradation with 25-70 percent of its theoretical oxygen demand demonstrated in the first 16 days (5). It is toxic to anaerobic digestion mechanisms, and like all nitriles can inhibit bacteria at high concentrations. Bacteria can acclimate, however, resulting in more rapid degradation. Although acrylonitrile is moderately soluble, biochemical action appears too slow to initiate harmful oxygen deficiencies in spill situations.

Acrylonitrile is toxic to fresh water fish at and below 100 ppm (1). Typical 96 hr median threshold limit values average 10-15 ppm for common species (1). Henderson et al. found slightly higher toxicity levels for hard water than for soft (1). Mixed aquatic biota appear to tolerate 10-25 ppm, but at 50 ppm growth is predominantly fungal (1).

As might be predicted by Henderson's work with hard water, saltwater toxicity data includes lower tolerable limits. In general, 20 ppm of acrylonitrile has deleterious effects on marine fish (1). Bluegill died when exposed to .05-1 ppm for 24 hours (20). Portman found a 48 hr Tlm of 24.5 ppm for pin perch (4) while median lethal concentrations of 10-33 ppm have been reported for shrimp (2).

Mammals in general tolerate a median lethal dose of 50-90 mg/kg (body weight 15). Acrylonitrile can be toxic when absorbed through the skin. Dermal applications to guinea pigs revealed an LD_{50} of 260 mg/kg body weight by that route of administration. Direct contact may produce welts on the skin. Chronic feeding to test rats and rabbits led to the establishment of 1 mg/kg body weight/day for six months and 10 mg/kg body weight/day for six months respectively as chronic threshold doses (15). While carcinogenic properties have not been attributed to acrylonitrile, it is known to react with D/RNA(19).

Other aquatic concentrations of interest include an odor threshold range of .0031-50.4 ppm (30) and drinking water limits of .2 ppm (7).

NAME Acrylonitrile

PRODUCTION QUANTITY 1,600 million lbs 1970 (185)

SYNONYMS Propenenitrile, Vinylcyanide, Cyanoethylene

COMMON SHIP OR CONTAINER SIZE Lined pails, drums, tank cars & tank trucks

DOT Flammable Liquid, Red Label, 10 gal. outside container

USCG Grade C flammable liquid

M.P. -82.0 °C

B.P. 78.3 °C

Sp.G. 0.807

SOLUBILITY 70,000 ppm at 25 °C

PERSISTENCE

Oxygen Demand

BOD_{10} = 25% Theo. using sewage seed in quiescent state-(5)
BOD_{10} = 25% Theo. using activated sludge at a treatment plant-(5)
BOD_{10} = 67% Theo. in river water with sewage seed-(5)
BOD_{10} = .7 lb/lb using sewage seed-(11)
BOD_{28} = 70% Theo. using treatment plant activated sludge and chemical analysis for N_2-(5)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
100.	24	Fish	100% kill		1
24.5	24	Perch	TLm		1
30	24	Perch	Lethal		1
18.1	96	Fathead Minnow	TLm	Soft	4
33.7	24	Fathead Minnow	TLm	Sat O_2, 25°C, Hard	4
18.7	48	Fathead Minnow	TLm	Sat O_2, 25°C, Hard	4
14.3	96	Fathead Minnow	TLm	Sat O_2, 25°C, Hard	4
34.3	24	Fathead Minnow	TLm	Sat O_2, 25°C, Soft	4

ppm	hrs	species	parm	cond	ref
21.5	48	Fathead Minnow	Tlm	Sat O2, 25°C, Hard	1
18.1	96	Fathead Minnow	Tlm	Sat O2, 25°C, Hard	1
25.5	24	Bluegill Sunfish	Tlm	Sat O2, 25°C, Soft	1
14.3	48	Bluegill Sunfish	Tlm	Sat O2, 25°C, Soft	1
11.0	96	Bluegill Sunfish	Tlm	Sat O2, 25°C, Soft	1
44.6	24	Guppy	Tlm	Sat O2, 25°C, Soft	1
33.5	48	Guppy	Tlm	Sat O2, 25°C, Soft	1
33.5	96	Guppy	Tlm	Sat O2, 25°C, Soft	1
11.0	96	Bluegill	Tlm	Hard	15
33.5	96	Guppy	Tlm	Hard	15

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
20		Saltwater Fish	Deleterious		1
.05-1	24	Bluegill	Lethal		20
10-25	48	Shrimp	LC50	Aerated	2
24.5	96	Pin Perch	Tlm	Soft	4

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	81	Oral	15
Mammals	50-95	Oral	15
Guinea Pig	360	Dermal	20

ADIPONITRILE

The 225 million lbs of adiponitrile produced in 1967 were primarily employed as intermediates in the manufacture of related polymers and organic chemicals. Production is projected to increase through the near future (198).

Adiponitrile does not dissociate in water to any appreciable extent (1). Consequently, little HCN is likely to be generated under normal conditions. Adiponitrile is, however, biodegradable with 40 percent of its theoretical oxygen demand realized in five days when dissolved in river water (5). This could be a sufficient kinetic rate to cause oxygen slumps in natural waters when spilled; however, adiponitriles limited solubility is likely to retard oxygen utilization. As with all nitriles, acclimation can have dramatic effects in accelerating biodegradation.

Henderson et al. tested several species of fish in hard and soft water to determine the toxicological characteristics of adiponitrile. They found significantly higher TLm values for soft water than for hard with those for bluegills in hard water averaging about 800 ppm and those in soft water 1,300 ppm (1). Sunfish and guppies appeared to be more sensitive to adiponitrile than fathead minnows (1). While salt water data does not exist, one would expect the trend to parallel that of acrylonitrile to which marine fish have a greater average sensitivity than fresh water fish. Fish exposed to 100 ppm for four weeks were found to have no loss of flesh quality tastewise (1).

Median lethal doses from oral administration range from 19.4-105 mg/kg body weight for mammals (15). Adiponitrile can be absorbed through the skin and subsequently exhibit toxic properties.

NAME Adiponitrile

PRODUCTION QUANTITY 225 million lbs 1967 (198)

SYNONYMS 1,4-Dicyanobutane, Tetramethylcyanide

USCG Grade E combustible liquid

M.P. 2.1 °C

B.P. 295.0 °C

Sp.G. .950

SOLUBILITY Slightly soluble

PERSISTENCE

Oxygen Demand

BOD_5 = 40% Theo in river water under quiescent conditions-(5)
BOD_{15} = 80% Theo with treatment plant activated sludge using chemical analysis for N_2- (5)
COD = 1.8 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
835	24	Fathead Minnow		Sat O_2, 25°C, Hard	1
821	48	Fathead Minnow		Sat O_2, 25°C, Hard	1
820	96	Fathead Minnow		Sat O_2, 25°C, Hard	1
1350	24	Fathead Minnow		Sat O_2, 25°C, Soft	1
1300	48	Fathead Minnow		Sat O_2, 25°C, Soft	1
1250	96	Fathead Minnow		Sat O_2, 25°C, Soft	1
1250	24	Sunfish		Sat O_2, 25°C, Soft	1
815	48	Sunfish		Sat O_2 25°C, Soft	1
720	96	Sunfish		Sat O_2 25°C, Soft	1
1200	24	Guppy		Sat O_2, 25°C, Soft	1
830	48	Guppy		Sat O_2, 25°C, Soft	1
775	96	Guppy		Sat O_2, 25°C, Soft	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	105	Oral	15
White Mouse	48	Oral	15
Rabbit	10.4	Oral	15

ALDRIN

Aldrin is a chlorinated hydrocarbon insecticide used in domestic and agricultural areas to control a variety of insects. The 10 million lbs produced in 1971 (327) were applied in granular or dust form, as a liquid, or in solution. Application varies from 2 oz.-6 lbs per acre.

While aldrin itself is soluble to only 0.27 ppm in water, it is commonly sold as a wettable powder or in solution with organic solvents and surfactants. These surfactants will facilitate dispersion of the insecticide if spilled into water. Aldrin can be oxidized to dieldrin under microbial activity. Aldrin mixed with river water dropped to 20 percent of its original concentration when left for eight weeks (328). Some inert diluents will catalyze decomposition. When applied at 100 ppm to sandy loam soil, however, one study found 40 percent remaining after 14 years. A dose of 25 ppm persisted at 50 percent for more than four years (22).

Aldrin is extremely toxic to aquatic life. The 96 hr TLm values for bluegill, fathead minnow, goldfish, and guppy have been reported as .013 ppm, .023 ppm, .028 ppm, and .033 ppm respectively (1). The 96 hr LC50 value for rainbow trout is .031 ppm (330). Crawfish are killed in the range .038-0.6 ppm (332). Aquatic microlife have similar sensitivity. The LC50 values for various anthropods and annelids range from

8 ppb to 45 ppm (22). Toxicity in bluegill was found to rise with water temperature (330). Suspended solids content may also be of importance since aldrin can be absorbed on sediments and deposited at the bottom.

In salt water, oysters display sublethal reactions to .001 ppm aldrin (404). A concentration of 1 ppm can cause a 95 percent reduction in oyster growth over a seven day exposure (22). Clam eggs were limited 70 percent in development when placed in .001 ppm aldrin (22). An average oral LD50 of 520 mg/Kg body weight has been found for waterfowl (165).

Aldrin is bioaccumulative. Algae can concentrate 1 ppm from water 150 fold in its protoplasm (22). Similarly, various plants, insects, animals, and reptiles have been found to concentrate aldrin from areas where application has occurred. Some species concentrate low levels to a point where the aldrin disrupts natural reproductive capacity (1).

Aldrin is highly hazardous when ingested. The oral LD50 for rats has been reported as 39-67 mg/Kg body weight. The estimated fatal dose for a 70 kg man is 5 gms (1). Drinking water is restricted to .017 ppm or less (337). In chronic feeding studies, dogs were found to have a threshold limit of 1 ppm (338) and waterfowl 5 mg/Kg/day (165). Aldrin has displayed carcinogenic potential. Mice fed a diet containing 10 ppm for two years showed a 74/215 occurrence of tumors (15).

Aldrin has some phytotoxic properties. Exposure of natural phytoplankton to 1 ppm for four hrs resulted in an 84.6 percent reduction in productivity (22). Many plants such as carrots, potatoes, peas, cabbage, cucumbers, beans, and radishes absorbed aldrin and held it in their tissues.

Aldrin has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

NAME Aldrin

PRODUCTION QUANTITY 10 million lbs - 1971 (327)

SYNONYMS Octalene, Compound 118, HHDN, 1,2,3,4,10,10-Hexachloro,
1,4,4a,5,8,8a-Hexahydroendo, exo-1,4:5,8-dimethanonapthalene

DOT Class B Poison if greater than 60 percent Aldrin

M.P. 40-60 °C technical 90 °C pure

Sp.G. 1.65

SOLUBILITY Insoluble-0.27 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
.130	24	Bluegill	LC50	Temp. 45°F	330
.0264	48	Bluegill	LC50	Temp. 45°F	330
.0097	96	Bluegill	LC50	Temp. 45°F	330
.0368	24	Bluegill	LC50	Temp. 55°F	330
.0125	48	Bluegill	LC50	Temp. 55°F	330
.0077	96	Bluegill	LC50	Temp. 55°F	330
.0164	24	Bluegill	LC50	Temp. 65°F	330
.0083	48	Bluegill	LC50	Temp. 65°F	330
.0062	96	Bluegill	LC50	Temp. 65°F	330
.0093	24	Bluegill	LC50	Temp. 75°F	330
.0067	48	Bluegill	LC50	Temp. 75°F	330
.0056	96	Bluegill	LC50	Temp. 75°F	330
.02	240	Goldfish	LC50		331
.05	24	Goldfish	LC50		331
.05	24	Rainbow	LC50		331
0.013	96	Bluegill	TLm		1
0.038	96	Fathead Minnow	TLm		1
0.028	96	Goldfish	TLm		1
0.033	96	Fathead Minnow	TLm		1
0.033	96	Guppies	TLm		1
0.64	24	Trout	50% Kill		329
0.036	24	Rainbow	LC50		330
0.031	48	Rainbow	LC50		330
0.031	96	Rainbow	LC50		330
1.0096	24	Bluegill	LC50		330
10		Lymnaeid Snails	100% Kill	Ditch Water	136
.018	120	Juvenile Crawfish	TLm		332
.6	120	Adult Crawfish	TLm		332
.143	96	Acroneuria Pacifica	TLm		333
0.009	96	Ephemerella Grandis	TLm		333

ALKYL ARYL SULFONATES (ABS)

Of the 748.3 million lbs of various alkylated benzene sulfonates produced in 1969, 74 percent of that total were in the form of calcium, potassium sodium isopropylamine, and triethanolamine salts of dodecylbenzenesulfonate or as the acid itself. All other alkyl benzene sulfonates accounted for 128 million lbs of which 128.9 million lbs were the sodium salt of tridecylbenzenesulfonate. ABS compounds are the most widely used group of anionic surfactants and are shipped in both bulk and containerized packages by rail, truck, and barge as white to yellow flakes or powder.

Because the fate and effect of the ABS materials are relatively independent of the chain-length and cation, all can be discussed as a group. ABS materials produced in sufficient quantities to be designated as hazardous are: dodecylbenzene sulfonic acid and the sodium, calcium, isopropanolamine and triethanolamine salts.

ABS materials dissolve rapidly in water where they are readily degraded by microflora, having BOD values in the range of 18-40% of the theoretical with acclimated seeds, (1,106). In regard to biodegradability, a distinction should be made concerning the terminology. Non-degradability was a problem generally associated with the branched chain benzene sulfonates, also referred to as ABS. The branched chain materials have been phased out in favor of the biodegradable linear alkyl benzene sulfonates (LAS) which are discussed here and now referred to as ABS. As surfactants, these materials display the ability to solubilize materials which might otherwise repel water. Sodium dodecyl benzene sulfonate can interfere

ppm	hrs	species	parm	cond	ref
18.5	96	Gammarus Lacustris	TLm		333
0.18	96	Pteronarcys Californica	TLm		333
.8 lb/acre		Crawfish	No Effect	Rice Field	334
.03	64	Daphnia Magna	Immobilization	70°F	335
.02-.6	96	Various Shiners	TLm	Aerated Pond Water	336
.6	48-192	Spot Fins	TLm	Aerated Pond Water	336
.2-.6	48-144	Sunfish	TLm	Aerated Pond Water	336
.2	48	Silverjaw Minnow	Lethal	Aerated Pond Water	336
.0013	96	(Naiads) Pteronarcys Californica	LC50	15.5°C	184
2	24	Fowlers Toad Tadpoles	LC50		22
.03	48	Simocephalus Serrulatus	EC50		22
26	48	Daphnia Pulex	LC50		22
0.01	24	Sand Shrimp	LC50		22
0.3	24	Hermit Crab	LC50		22
.2	24	Grass Shrimp	LC50		22
45	24	Amphipod	LC50		22
0.008	48	Stonefly	LC50		22
14	48	Amphipod	LC50		22

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
.01	96	Oyster	Sublethal Effects		404
.001	96	Oyster	Sublethal Effects		404
1	7 Days	Oyster	95% Red. in Growth		22
.001		Clam Eggs	70% Limited in Development		22
0.025	96	Oyster	LC50		437

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	25	Oral	1
Rat	67	Oral	1
Rat	56-58	Oral	22
Rabbit	>150	Oral	22

with normal biochemical systems in water. The presence of 300 ppm ABS causes the development of reducing flora which then produce sulfides. A level of 60 ppm retards the development of proteolytic bacteria, while 15-60 ppm had similar effects on aerobic bacteria. Denitrification is retarded at 150 ppm (1).

These materials are highly toxic to aquatic life with fresh water fish Tlm values ranging between 4 and 18 ppm depending on the test species (1). Deleterious effects have been noted in silver salmon exposed to 5.6 ppm (1). Fish food organisms are destroyed at similar levels. The Tlm values for Daphnia magna have been reported at 12-50 ppm (1). Phytotoxic action toward phytoplankton has been observed with a concentration of 120 ppm (1). Saltwater fish are sensitive to ABS in the range of 7.5 to 22.5 ppm as shown by 96 hour Tlm's to eel, flounder, mullet, and mummichog (293). Shellfish reproduction appears to be particularly sensitive with as low as 0.5 ppm causing egg sterilization in the oyster while 0.55 ppm inhibited larval development in the clam (40).

Mammals are resistant to ABS intoxication with reported oral LD_{50} values between 1400 and 2800 mg/kg of body weight for rats and mice (1). Taste and odor problems can be created in potable water supplies with concentrations less than 1 ppm (1). Frothing and nuisance foam may result from .5-1 ppm (1).

ALKYL ARYL SULFONATES

MATERIALS OF INTEREST - Dodecylbenzene Sulfonic Acid, Sodium Salt, Calcium Salt, Isopropanolamine Salt, Triethanolamine Salt

PRODUCTION QUANTITY - 740 million lbs 1969

SYNONYMS - ABS

COMMON SHIP OR CONTAINER SIZE - Containerized and bulk

SOLUBILITY - Soluble

PERSISTENCE

Oxygen Demand - Sodium Decylbenzene Sulfonate: 10% Theo. BOD_5 with acclimation activated sludge - (11); 46% Theo. BOD_{20} with acclimated activated sludge - (11)

Sodium Dodecylbenzene Sulfonate: 13% Theo. BOD_{10} with activated sludge - (11); 30% Theo. BOD_{20} with activated sludge - (11); 41% Theo. BOD_5 with activated sludge - (11).

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	pasm	cond	ref
Disodiumdibutylphenylphenoldisulfonate					
500	.5	Stagnicola Reflexa	Molluscacidal Effect		1
5000	.3	Stagnicola Reflexa	Molluscacidal Effect		1
10,000	.16	Stagnicola Reflexa	Molluscacidal Effect		1
20,000	.10	Stagnicola Reflexa	Molluscacidal Effect		1
50,000	.08	Stagnicola Reflexa	Molluscacidal Effect		1
Sodium Butyldiphenyl Sulfonate					
500	.33	Stagnicola Reflexa	Molluscacidal Effect		1
5000	.25	Stagnicola Reflexa	Molluscacidal Effect		1
10,000	.20	Stagnicola Reflexa	Molluscacidal Effect		1
20,000	.17	Stagnicola Reflexa	Molluscacidal Effect		1
50,000	.15	Stagnicola Reflexa	Molluscacidal Effect		1

ppm	hrs	species	parm	cond	ref
Sodium Butylphenylphenol Sulfonate					
5	336	Goldfish	0% Kill	Alkyl Aryl Sulfonate	1
10	48	Goldfish	30% Kill	Alkyl Aryl Sulfonate	1
15	6	Goldfish	100% Kill	Alkyl Aryl Sulfonate	1
.5	.33	Stagnicola Reflexa	Molluscacidal Effect		1
5	.18	Stagnicola Reflexa	Molluscacidal Effect		1
10	.13	Stagnicola Reflexa	Molluscacidal Effect		1
20	.10	Stagnicola Reflexa	Molluscacidal Effect		1
50	.06	Stagnicola Reflexa	Molluscacidal Effect		1
Sodium Decylbenzene Sulfonate					
5.6		Silver Salmon	Deleterious Effect	Aerated Lake	1
500	.40	Stagnicola Reflexa	Molluscacidal Effect		1
5000	.17	Stagnicola Reflexa	Molluscacidal Effect		1
10,000	.12	Stagnicola Reflexa	Molluscacidal Effect		1
20,000	.10	Stagnicola Reflexa	Molluscacidal Effect		1
50,000	.10	Stagnicola Reflexa	Molluscacidal Effect		1
Sodium Dodecylbenzene Sulfonate					
120		Algae	Growth Stopped		1
8		Fish	Died	Sewage Trt. Plant	1
10		Roach & Rhodeus	Limiting		1
16		Idus & Carp	Limiting		1
3	288	Trout	TLm	Oxygenated	1
10	48	Goldfish	30% Died	Aerated	1
15	6	Goldfish	100% Died	Aerated	1
6		Fish	Minimum Lethal	Distilled 18°	1
6		Fish	Minimum Lethal	Hard 23°	1

Sodium Dodecylbenzene Sulfonate

ppm	hrs	species	parm	cond	ref	
[illegible]	24	Fish	TLm	Soft	1	(100% ABS)
[illegible]	48	Fish	TLm	Soft	1	"
[illegible]	96	Fish	TLm	Soft	1	"
[illegible]	24	Fish	TLm	Hard	1	"
[illegible]	48	Fish	TLm	Hard	1	"
[illegible]	96	Fish	TLm	Hard	1	"
[illegible]	24	Bluegill	TLm	Soft	1	"
[illegible]	48	Bluegill	TLm	Soft	1	"
[illegible]	96	Bluegill	TLm	Soft	1	"
[illegible]	24	Fish	TLm	Soft	1	(85% ABS)
[illegible]	48 & 96	Fish	TLm	Soft	1	(15% Inert)
[illegible]	24;48;96	Fish	TLm	Hard	1	
[illegible]	24;48;96	Fish	TLm	Soft	1	(60% ABS)
[illegible]	24;48;96	Fish	TLm	Hard	1	(40% Inert)
[illegible]	24;48;96	Fish	TLm	Soft	1	(40% ABS)
[illegible]	24;48;96	Fish	TLm	Hard	1	(60% Inert)
[illegible]	24	Fish	TLm	Soft	1	(31% ABS)
[illegible]	48&96	Fish	TLm	Soft	1	(57% Sod.)
[illegible]	24&48	Fish	TLm	Hard	1	(Tripolyphos-
[illegible]	96	Fish	TLm	Hard	1	phate)
[illegible]	24	Fish	TLm	Soft	1	(30% ABS)
[illegible]	48	Fish	TLm	Soft	1	(27% STP)
[illegible]	96	Fish	TLm	Soft	1	(20% Sod.
						Sulfate)
20	24	Fish	TLm	Hard	1	
16	48	Fish	TLm	Hard	1	
15	96	Fish	TLm	Hard	1	
[illegible]	24	Fish	TLm	Soft	1	(22% ABS)
[illegible]	48	Fish	TLm	Soft	1	(6% Alkyl
[illegible]	96	Fish	TLm	Soft	1	Sulfate)
						(65% Sod.
						Sulfate)
[illegible]	24;48;96	Fish	TLm	Hard	1	
[illegible]	24;48;96	Fish	TLm	Soft	1	(18% ABS)
[illegible]	24&48	Fish	TLm	Hard	1	(47% STP)
						(25% Sod.
						Sulfate)
[illegible]	96	Fish	TLm	Hard	1	
59	24,48,96	Fish	TLm	Soft	1	(9% ABS)
100	24	Fish	TLm	Hard	1	(6% Alkyl
90	48	Fish	TLm	Hard	1	Sulfate)
87	96	Fish	TLm	Hard	1	(50% STP)
						(20% Sod.
						Sulfate)

ppm	hrs	species	param.	cond	ref
20	1	Trout, 10 day old	Death		1
12	6	Trout, 10 day old	Death		1
20	1	Trout, 65 day old	Death		1
10	6	Trout, 65 day old	Death		1
15	1	Trout, 4 cm long	Death		1
12	6	Trout, 4 cm long	Death		1
20	1	Trout, 8 cm long	Death		1
12	6	Trout, 8 cm long	Death		1
15	1	Trout, 15 cm long	Death		1
7	6	Trout, 15 cm long	Death		1
5	24,48,96	Daphnia	<20% Died		1
10	24	Daphnia	<20% Died		1
10	48	Daphnia	20-80% Died		1
10	96	Daphnia	<20% Lived		1
15	24	Daphnia	20-80% Lived		1
15	48&96	Daphnia	All Died		1
35	24,48,96	Daphnia	All Died		1
50	24,48,96	Daphnia	All Died		1
17.4	96	Bluegill	TLm		167
21.9	96	Pumpkinseed	TLm		167
5.0	20-30	Trout	Lethal		293
3.7	24	Trout	TLm		293
5.0		Trout	Gill Pathology		293
4.2	24	Bluegill	TLm		293
3.7	48	Bluegill	TLm		293
10.0	96	Bluegill	TLm		293
3.1	168	Fathead Fry	TLm		293
5.6	72	Salmon	Lethal		293
1.0	240	Yellow Bullheads	Histo-pathology		293
7.4	96	Emerald Shiner	TLm		293
7.7	96	Bluntnose Minnow	TLm		293
8.9	96	Stoneroller	TLm		293
9.2	96	Silver Jaw	TLm		293

ppm	hrs	species	parm	cond	ref
9.5	96	Rosefin	TLm		293
17.0	96	Common Shiner	TLm		293
18.0	96	Carp	TLm		293
22.0	96	Black Bullhead	TLm		293

Sodium Nitrochlorobenzene Sulfonate

318	100	Daphnia Magna	0% Kill	23°C	1
1474	100	Daphnia Magna	50% Kill	23°C	1
3187	100	Daphnia Magna	100% Kill	23°C	1
6375	96	Bluegill	TLm	Lake	59
1532	24	Lymnaea Sp Eggs	TLm	Lake	59
3208	48	Lymnaea Sp Eggs	TLm	Lake	59

Salt Water Toxicity

Sodium Dodecylbenzene Sulfonate

2.5	14 days	Clam	Egg Sterilization		40
.5	14 days	Oyster	Egg Sterilization		40
.14- 1.5		Oyster	Larvae Inhibition		40
.55-1		Clam	Larvae Inhibition		40
7.0	96	Silverside	TLm	20% Salt	293
7.5	96	American Eel	TLm		293
8.2	96	Winter Flounder	TLm		293
10.1	96	Mullet	TLm		293
22.5	96	Mummichog	TLm		293

Mammalian

Disodium dibutylphenylphenoldisulfonate

species	mg/kg B. W.	administration route	ref
Mice	2200	Oral	1

Sodium Butyldiphenyl Sulfonate

Mice	1500	Oral	1
Mice	1400	Oral	291

Species	mg/kg B. W.	administration route	ref
Sodium Butylphenylphenol Sulfonate			
Mice	[illegible]	Oral	[illegible]
Mice	[illegible]	Oral	[illegible]
Sodium Decylbenzene Sulfonate			
Mice	[illegible]	Oral	[illegible]
Rat	[illegible]	Oral	[illegible]
Mice	[illegible]	Oral	[illegible]
Sodium Dodecylbenzene Sulfonate			
Rat	1400	Oral	[illegible]
Mice	[illegible]	Oral	[illegible]
Rat	[illegible]	Oral	[illegible]
Rat	105	Intravenous	[illegible]
Alkyl Aryl Sulfonate			
Rat	1400	Oral	[illegible]

ALLYL ALCOHOL

Allyl alcohol has been used in war gas, but is more commonly thought of as a resin and plastics building block. One and five gallon cans, drums, tank trucks, tank cars, and tank barges were used to transport the 16,110,000 lbs produced in 1963 (199).

Allyl alcohol polymerizes slowly upon standing to an insoluble polymer. This process is not expected to occur in solution. The unsaturated bond, however, is subject to photochemical attack over a period of time. Though miscible, allyl alcohol is not likely to produce appreciable oxygen deficiences when spilled in water. Degradation rates are quite slow, averaging 4-5 percent per day over the first 20 days (15,36).

Allyl alcohol is considered toxic to aquatic life. A threshold of 10 ppm has been reported for Rudd in fresh water (1). The entire population of fathead minnows was killed when exposed to 1 ppm for 72 hours, while no toxic effects were noted at 0.2 ppm (426). Similarly, marine species are affected in the 1-100 ppm range (1,2). Portman found cockles and starfish the least sensitive of the macro-invertebrates tested (2).

Allyl alcohol can also be quite toxic when ingested by mammals. LD50 values predominate in the 40-100 mg/kg body weight range (1,15). Experiments on rats showed weight retardation at concentrations of 250 mg/l in the drinking water. However, major effects were not noted even at 1000 mg(1). Allyl alcohol is known to be a strong local irritant which can be absorbed through the skin. It is also known to react with t/RNA (19).

NAME Allyl Alcohol

PRODUCTION QUANTITY 16,110,000 lb 1963 (190)

SYNONYMS 2 Propen-1-Ol, 1-Propenol-3, Vinyl Carbinol

COMMON SHIP OR CONTAINER SIZE 1 & 5 gal cans, drums, tank trucks
and cars, tank barges

DOT Class B Poison, Poison Label, 55 gal outside container

USCG Grade C Flammable, Class B poison

M.P. 129.0 °C

B.P. 96.000 °C

Sp.G. 0.854

SOLUBILITY Miscible

PERSISTENCE

Oxygen Demand

BOD_5 = .2 lb/lb with sewage seed (11)
BOD_5 = 9.1% theo. with sewage seed (36)
BOD_{10} = 57% removed with non-flocculent growth activated sludge (10)
BOD_{20} = 81.8% theo. with sewage seed (36)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
10		Rudd	Threshold		1
1	72	Fathead Minnow	100% Kill	50°F, Huron	426
0.75	72	Fathead Minnow	Partial Kill	50°F, Huron	426
0.2	72	Fathead Minnow	No Toxic Effect	50°F, Huron	426

Salt Water Toxicity

ppm	hrs	species	para	cond	ref
2.5		Bivalve Larvae	Lethal		1
1-10	48	Shrimp	LC50	Aerated	2
>100	48	Cockle	LC50	Aerated	2
>11	48	Starfish	LC50	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	40	Oral	1
Rat	100	Oral	1
Rat	64	Oral	15

ALLYL CHLORIDE

Allyl chloride is primarily employed as an intermediate in the production of glycerine, resins, and fine chemicals. Tank cars and 55 gallon drums were generally used to ship the 465 million lbs produced in 1971 (198).

Allyl chloride produces hydrogen chloride upon storage and can similarly undergo hydrolysis in water to allyl alcohol and hydrochloric acid. This process is inhibited by the compound's low solubility but can be accelerated with caustic. Exposure to heat and sunlight can lead to photodegradation of the unsaturated bond. Since allyl alcohol is the primary hydrolysis product, biodegradation is expected to be quite slow. No oxygen deficiencies are expected to occur in spill situations.

Limited toxicity data is available, but Tlm values of 20-50 ppm are typical for common freshwater fish species (37). Bluegill and guppy appear to be more resistant than goldfish and fathead minnows (37). In saltwater, the 96 hr Tlm for sheepshead minnows is 24 ppm (426).

Allyl chloride is a strong local irritant capable of killing rats when present in air at 300 ppm (18). It can be absorbed through the skin and is considered highly toxic via all administration routes (38). Baker reports an odor detection threshold of 3660-29300 ppm (30). The Shell Chemical Company lists the odor threshold in air as 1-25 ppm with eye irritation noted at 50-100 ppm (19).

NAME Allyl Chloride

PRODUCTION QUANTITY 465 million lbs 1971 (192)

SYNONYMS 3-Chloropropylene, AC, Chlorallylene, 3-Chloropropene,
α-Chloropropylene

COMMON SHIP OR CONTAINER SIZE Tank cars, 55 gal drums

USCG Grade B flammable, Class B poison

M.P. -134.5 °C

B.P. 45.0 °C

Sp.G. 0.90

SOLUBILITY 3000 ppm at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
24	96	Fathead Minnow	Tlm	Const. Temp.	17
42	96	Bluegill	Tlm	Const. Temp.	17
22	96	Goldfish	Tlm	Const. Temp.	17
48	96	Guppy	Tlm	Const. Temp.	17

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
24	96	Sheepshead Minnow	Tlm		426

ALUMINUM SULFATE

This white crystalline compound is known in the trade by the various names of alum, pearl alum, pickle alum, cake alum, filter alum, papermaker's alum, and patent alum. About 2.5 billion pounds of aluminum sulfate was produced in 1971 in the United States. Almost two-thirds of this total is used by the paper industry for the clarification of process waters, pH control of pulp slurries, setting of certain dyes, and setting of size in the paper. More than one-fourth is used in water treatment uses. Various other uses, such as chemical manufacture, pharmaceutical preparation, dyeing, tanning, clarification of fats and oils, decolorization in petroleum refinery processes, fire-extinguishing solutions, waterproofing agent for concrete, ethane-production catalysts, and food additives account for the remainder. Aluminum sulfate crystals are shipped in bags, fiber drums, multiwall paper sacks, and, for bulk shipment, in carloads. As a solution, it is shipped in rubber-lined tank cars and trucks.

Aluminum sulfate is readily soluble in water. When spilled it will sink and dissolve, forming an acid solution. The low pH results from formation of aluminum hydroxide which then precipitates out. Natural dilution and buffer capacity will lower the concentration of residual aluminum after a spill. Aluminum sulfate may interfere with natural biological processes. As little as 10 ppm has been found to inhibit sewage organisms by 50 percent.

Aluminum sulfate can be quite toxic to fish. As little as 7 mg/l killed Fundulus in 1400 hr while 14 mg/l was fatal in 18 hr (1). The 96 hr TLm for mosquito fish in turbid water is reported to be 235 ppm (1). The threshold for immobilization of Daphnia magna is 106 ppm (1). Chronic exposure limits for Daphnia have also been reported as 136 ppm (55).

Aluminum sulfate can be toxic when ingested. The oral LD50 for mice is reported to be 770 mg/kg body weight (215). Drinking water should not contain more than 0.1 ppm aluminum (40). A concentration of 0.1 ppm alum in swimming water can cause mild eye irritation, while 0.5 ppm is acutely irritating (1).

Aluminum sulfate can be harmful to plants. Irrigation water with 25 mg/l was found to reduce growth in oats (1). Irrigation water in general should not contain more than 1 ppm aluminum (40).

NAME Aluminum Sulfate

PRODUCTION QUANTITY 2.3 billion lbs 1971

SYNONYMS Cake Alum, Patent Alum, Filter Alum, Pickle Alum

COMMON SHIP OR CONTAINER SIZE Bulk carloads, barrels, drums,
bags, kegs, bottles

M.P. 86.5 °C

B.P. Decomposes at 770°C

Sp.G. 1.69

SOLUBILITY 310,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, etc.

Hydroxide is insoluble and soon precipitates with neutralization.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
7	1200	Fundulus	Fatal		1
14	36	Fundulus	Fatal		1
250	6-24	Goldfish, Sunfish	Killed		1
235	96	Mosquito Fish	TLm	Turbid	1
136		Daphnia Magna	Threshold Immobilization		1
250	96	Largemouth Bass	LC50		428

Mammalian

species	mg/kg B. W.	administration route	ref
Mouse	770	Oral	215

AMMONIA

Ammonia gas is used extensively for the production of fertilizer, explosives, synthetic fibers, nitric acid, and amines. The 28 billion lbs produced in 1971 (199) were shipped as a gas, a liquified gas, and in solution in steel cylinders, tank cars, tank trucks, and tank barges.

Ammonia gas is soluble in water to 100,000 ppm. Spills of the gaseous material, however, may not result in massive ammonia contamination because of poor interfacial contact. Spills of liquified ammonia or aqueous solutions will rapidly disperse through the water column. Ammonia quickly forms ammonia hydroxide in water accompanied by the generation of great heat and an elevation of pH. Product ammonia hydroxide dissociates partially such that at pH 6, the ratio of ammonium ion to the combined form is 1000 while at pH 8, it is 10 (1). Ammonia in neutral or basic solutions will volatilize and escape to deplete high concentrations. Bacterial life can utilize ammonia by converting it to nitrate. This process creates an oxygen demand but usually does not occur until several days after introduction of the ammonia.

Ammonia can be toxic to many forms of aquatic life. Various lethal and toxic effects have been noted in fish exposed to .3-17 ppm ammonia. (1) An ammonia concentration of 1.0 mg/l decreases the ability of fishes' hemoglobin to combine with oxygen. (1) The 96 hr TLm for bluegill is reported as 3.1-3.4 ppm in soft water and 23.7-24.4 ppm in hard water. (1) Various forms of fish food organisms show toxic reactions at 90-420 ppm (1). Daphnia, however are killed by 8 ppm ammonia. (1) In general, the threshold concentration for fish is 0.5 ppm free ammonia. (41) Although algae thrive on high nitrate concentrations they appear to be harmed when the nitrogen is in the ammonia form. (1) Stammer reports the following toxicity threshold values for indicator organisms in a saprophytic system: - oligosaprobic and B-mesosaprobic zones, 0.0-0.4 mg/l; .2 - mesosaprobic zones, 0.1-4.1 mg/l; and polysaprobic zone, 1.2-220 mg/l (1).

Ammonia is considered toxic when inhaled or ingested. Rabbits fed 50-80 mls of 0.5 percent ammonia for 17 mos. (80-130 mg/kg body weight/day) suffered chronic acidosis and tissue changes. (15) Livestock should not be fed more than 170 gm of ammonia. (7) A level of 100 ppm can inhibit germination in birds. (243) Water for human consumption should be limited to .05 ppm ammonia. (48) This level, however, is predicated more on organoleptic properties than toxic effects. Ammonia causes odors when present in water in the range .32-2.6 ppm (244) and tastes when present at .037 ppm. (127)

Ammoniacal solutions can be irritating. Water for body contact should not exceed 1.0 ppm ammonia. (48)

NAME Ammonia

PRODUCTION QUANTITY 28 billion lbs. - 1971

COMMON SHIP OR CONTAINER SIZE Cylinders, tank trucks, tank cars, tank barge

DOT Nonflammable compressed gas, green label, 300 lbs. in an outside container

USCG Liquified compressed gas

M.P. -77.7 °C

B.P. -33.4 °C

Sp.G. 0.680 as a liquid

SOLUBILITY 105,000 mg/l @ 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
5-7	6	Minnows	Toxic or Lethal	Distilled 20 °C	1
6-7	6	Minnows	Toxic or Lethal	Hard 20 °C	1
7-8	1	Sunfish	Toxic or Lethal	"	1
17.1	1	Minnows	Toxic or Lethal	"	1
17-136	1	Trout, Eel, Roach	Toxic or Lethal	"	1
23.7	96	Sunfish	TLm	Hard 30 °C	1
24.6	96	Sunfish	TLm	Hard 20 °C	1
75.7	<.05	Trout	Toxic or Lethal	"	1
90	96	Snail	TLm	Soft 20 °C	1
134.9	96	Snail	TLm	Hard 20 °C	1
94.5	96	Snail	TLm	Soft 30 °C	1
133.9	96	Snail	TLm	Hard 30 °C	1
420	120	Diatom	50% Red. Growth	Soft 22 °C	1
420	120	Diatom	50% Red. Growth	Hard 22 °C	1
320	120	Diatom	50% Red. Growth	Soft 28 °C	1
420	120	Diatom	50% Red. Growth	Hard 28 °C	1

ppm	hrs	species	parm	cond	ref
410	120	Diatom	50% Red. Growth	Soft 30 °C	1
350	120	Diatom	50% Red. Growth	Hard 30 °C	1
8	-	Daphnia	Lethal	-	1
0.41	48	Rainbow Trout	TLm		242
.3-.41	-	Trout Fry	Toxic or Lethal	-	1
.6	~1.5	Rainbow Trout	Toxic or Lethal	-	1
.7	6 1/2	Rainbow Trout	Toxic or Lethal	-	1
1-2	-	Fish	Toxic or Lethal	-	1
1.2	3.2	Squalius Cephalus	Toxic or Lethal	-	1
2-2.5	24 to 96	Goldfish	Toxic or Lethal	-	1
2.9	13	Cichla Ocellaris	Toxic or Lethal	-	1
3.1	96	Sunfish	TLm	Soft 20 °C	1
3.4	96	Sunfish	TLm	Soft 20 °C	1
5	-	Trout Rainbow	Toxic or Lethal	-	1

AMMONIUM SALTS

Ammonium salts are common throughout agriculture and industry. They are employed for such widespread activities as meat preservation, dyeing, veterinary medicine, fertilization, ink production, wool scouring, tanning, soldering, and textile printing. Many ammonium salts are produced and shipped in bulk as both dry and solution mixes

Ammonium salts are readily soluble in water and will soon disperse when spilled. Solution pH may drop after dispersion due to formation of dissolved ammonium hydroxide.

The tendency to associate is quite strong. The ratio of ammonium ion to the combined form is 1000 at pH 6 and 10 at pH 8 (1). As solution pH rises further, some ammonium is lost as free ammonia gas. Bacterial activity will convert ammonia to nitrate with a concomitant demand for dissolved oxygen. The resulting BOD is typically evidenced several days after introduction of the ammonium compound.

The toxicity of most ammonium salts is directly related to the amount of undissociated ammonium hydroxide created in the water, which in turn is a function of solution pH. Hence, Ellis found that toxicity of various ammonium salts toward fish increased by 200 percent or more when solution pH was raised from 7.4 to 8.0 (1). In general, common salts such as the sulfate are hazardous to fish in the 56-500 ppm range (1). When combined as the hydroxide, however, the lethal

lethal range is 4-37 ppm (1). The 48 hr TLm for the combined form has been reported as .15 ppm, and 17.5 ppm for bluegill and fathead minnows respectively. A concentration of 6.25 ppm NH_4OH killed trout in 24 hrs (1). Similarly, microlife such as Daphnia are immobilized by 0.75 ppm (1). Algae, which thrives on nitrate, appears to be inhibited when nitrogen is present in the ammonia form.

Ammonium salts can be quite toxic to mammals. Laboratory animals have been found to display LD_{50} values around 100 mg/Kg body weight when administered ammonium salts intravenously (8). On the other hand, some of the more common compounds such as the carbonate are used in cooking preparations (1).

Ammonium ion does not display the severe organoleptic properties attributed to free ammonia. If solution conditions cause the formation of free ammonia, however, drinking water should be limited to .05 ppm or less. These solutions might also be irritating upon contact if ammonia content exceeds 1 ppm (40).

AMMONIUM ACETATE

Ammonium acetate is primarily used for the preservation of meat, in dying and veterinary applications, and as a chemical reagent. Some 1 million lbs were produced in 1968 (199).

Ammonium acetate tends to lose ammonia upon standing. Under alkaline conditions, this situation will be pronounced, while under acid conditions it will be suppressed. As a highly soluble material with a rapid biochemical oxygen demand rate, 79 percent in 1-5 days, this material may well cause an oxygen slump when spilled. If carried to completion, the demand curve will be stair-stepped, demonstrating a plateau around the five day point. The initial rise will be due to acetate utilization and the final to ammonia utilization.

Limited aquatic toxicity data indicates a median threshold limit of 238 ppm for mosquito fish (1). This is somewhat less than the 436 ppm 96 hr TLm found for ammonium chloride under similar conditions. In general, free ammonia has a toxic threshold to fish of 0.5 ppm (11). It is presumed that the turbidity masked some of the toxic nature of the acetate salt in the aforementioned test.

Mice fed intravenously suffered an LD50 of 98 mg/kg body weight (8). The somewhat acid solution is also capable of producing irritation.

NAME Ammonium Acetate

M.P. 112. °C

B.P. 200. °C Decomposes

Sp.G. 1.073

SOLUBILITY >1,000,000 ppm at 25°C

PERSISTENCE

Oxygen Demand

BOD_{1-5} = 79% Theo. with activated sludge in a respirometer (10)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
238	24	Mosquito Fish	TLm	Turbid at pH 7.6-8.4	1
238	48	Mosquito Fish	TLm	Turbid at pH 7.6-8.4	1
238	96	Mosquito Fish	TLm	Turbid at pH 7.6-8.4	1

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	98	intravenous	8

AMMONIUM BENZOATE

M.P. = Decomposes at 198°C

B.P. = Sublimes at 160°C

Sp. G. = 1.260

SOLUBILITY = 196,000 mg/l at 14.5°C

PERSISTENCE

Oxygen Demand - Dissociates to ammonium and benzoate ion. Benzoate has a BOD_5 1.4 lb/lb (71% theoretical).(1) Ammonium will oxidize to nitrate after a period of 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity

Toxicity will be that for the more persistent ammonium ion.

AMMONIUM BICARBONATE

SYNONYMS - Ammonium hydrogen Carbonate, Ammonium Acid Carbonate, Acid Ammonium Carbonate

COMMON SHIP OR CONTAINER SIZE - 100 lb drums, carloads

M.P. 107.5°C

B.P. Sublimes

Sp. G. - 1.58

SOLUBILITY - 119,000 mg/l at 0°C

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Bicarbonate equilibrates with natural alkalinity. Ammonium ion will oxidize to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be determined by the state of the ammonium ion.

Mammalian Toxicity

Species	mg/kg B. W.	ministration Route	Ref
Mice	0.234	Intravenous	96

AMMONIUM BISULFITE

SYNONYMS- Ammonium Hydrogen Sulfite, Ammonium Acid Sulfite

M.P. Decomposes

Sp. G. - 2.03

SOLUBILITY - Freely soluble

TOXICOLOGICAL:

Freshwater Toxicity - Toxicity is related to the ammonium ion.

AMMONIUM BROMIDE

M.P. - Sublimes at 542°C

B.P. 396°C

Sp. G. - 2.327

SOLUBILITY - 680,000 mg/l

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Ammonium ion will oxidize to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be related to the ammonium ion.

AMMONIUM CARBAMATE

B.P. - Sublimes at 60°C

SOLUBILITY - 250,000 mg/l

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates. Ammonium ion will oxidize to nitrate in 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will depend upon ammonium ion.

AMMONIUM CARBONATE

Ammonium carbonate is used in a variety of ways, including as a food additive for baking powder, in wool scouring and textile printing, in ink, and for leather tanning. It is presently marketed by nine major U. S. firms.

Ammonium carbonate is a highly unstable compound. Contact with air or warm water results in release of free ammonia. Aqueous solutions are alkaline and hence sponsor the formation of toxic NH_4OH. While biochemical oxygen demand data is not available, the ammonia radical can act as free ammonia which undergoes oxidation to the nitrate form. This process is a slow one and usually occurs after several days. Consequently, the highly soluble carbonate salt should not produce oxygen deficiencies in spill situations.

Aquatic toxicity data varies considerably. The toxic threshold for freshwater fish appears to lie between 10-40 ppm with one source reporting 5.5-7 ppm lethal to fish (1). It would appear that the discrepancy is due to the resulting pH of the solution which is the critical parameter of concern. Alkaline conditions increase toxicity. Generally speaking, the threshold concentration for fish is .5 ppm free ammonia (4).

The median lethal dose for mice was determined via intravenous administration to be 96 mg/Kg body weight (41).

lower doses have been used for medicinal purposes in humans and other mammals (8).

Other aqueous concentrations of interest include a lower odor threshold of .5 ppm ammonia (1), recommended drinking water limits of .05 ppm ammonia (40), and a body contact exposure limit of 1 ppm ammonia (40).

NAME Ammonium Carbonate

SYNONYMS Crystal Ammonia, Sal Volatile, Hartshorn

M.P. 58.0°C Decomposes

Sp.G. 1.917

SOLUBILITY 405,000 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
240	1.5	Goldfish	Killed	Distilled	1
10	>100	Goldfish	Tolerated		1
5.5-7		Fish	Lethal		1
35		Fish	Threshold		1
48	144	Goldfish	Killed	Hard	1
100	4-10	Goldfish	Killed	Hard	1
155-197	Few	Shiners & Carp	Fatal		1
288	96	Mosquito Fish	TLm	Turbid	1
100-800	1	Sunfish	Killed		1

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	96	Intravenous	41

AMMONIUM CHLORIDE

Ammonium chloride is commonly employed in tanning, soldering, veterinary work, and in dry cell batteries. The 26.6 thousand tons short produced in 1965 (198) were shipped in drums, kegs, 100 lb bags, and 300 lb barrels.

Ammonium chloride is readily soluble in water, forming an acidic solution. Presence of alkaline conditions will sponsor production of toxic NH_4OH and will cause the release of gaseous NH_3. Ammonia is subject to bacterial attack. Oxidation to the nitrate form however takes several days to reach a state where oxygen demand is of importance. Hence, no oxygen slump is expected in spill situations.

Ammonium chloride is generally less toxic to fish than the carbonate because of its ability to drive the solution pH down. Threshold limits in hard water generally begin above 200 ppm for fish (1). Rainbow trout have been killed at levels as low as 24.6 over a 48 hr period (44). Aquatic invertebrates were found to be immobilized at much lower levels(1). The variance in toxic levels can be attributed to several basic parameters. Toxicity goes up with pH due to the formation of toxic NH_4OH. Threshold toxicity values decrease with decreasing oxygen tension. Finally, salinity increases toxicity. The latter can be seen through parallel tests run with minnows in hard and distilled water. The minimum lethal concentrations were 100 ppm and 4000 ppm, respectively (1).

As might be predicted, trout and salmon in salt water exhibit low 24 hr median threshold limits: 85 ppm and 45 ppm, respectively (46).

Median lethal doses have been determined as 30 mg/Kg body weight for rats fed intramuscularly (8), and 240 mg/Kg body weight for guinea pigs fed intravbnously (47). Medicinal doses range from .5-1 gram.

Other aquatic concentrations of interest include recommended drinking water limits of .05 ppm free ammonia (40) and a body contact exposure limit of 1 ppm free ammonia (40). Chloride should be kept below 3000 ppm for livestock (41) and 500 ppm for use on citrus plants (41). Vegetables can tolerate up to 750 ppm chlorides (41).

NAME Ammonium Chloride

PRODUCTION QUANTITY 26.6 Thousand Tons Short, 1965 (198)

SYNONYMS Ammonium Muriate, Sal Ammonia, Salmiac

COMMON SHIP OR CONTAINER SIZE drums, kegs, 100 lb bags,
300 lb barrels

M.P. 350 °C Decomposes

B.P. 520 °C Sublimes

Sp.G. 1.53

SOLUBILITY 297,000 ppm at 25°C

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	species	parm	cond	ref
6	96	Sunfish	TLm		1
368	144	Goldfish	Killed	Hard	1
300	6	Minnows	Minimum Lethal	Hard	1
314		Trout	Toxic Threshold		1
490	96	Mosquito Fish	TLm	Turbid	1
535	4.75	Bluegill	Killed	Tap	1
535	412	Bluegill	Killed	Distilled	1
700-800	1	Sunfish	Killed		1
1570		Rainbow Trout	Lethal		1
4000	6	Minnows	Minimum Lethal	Distilled	1
535	6	Daphnia	Killed	Distilled	1
<2		Daphnia Young	Immobilized	Lake Erie Water 20-25°C	1
1.1		Leptodora Kindtii	Immobilized	Lake Erie Water 20-25°C	1
86		Cyclops Vernalis	Immobilized	Lake Erie Water 20-25°C	1
75		Mesocyclops Leukarti	Immobilized	Lake Erie Water 20-25°C	1
5		Diaptomus Oregonensis	Immobilized	Lake Erie Water 20-25°C	1
24.6	48	Rainbow Trout	TLm		44
500	6	Rainbow Trout	Killed	18°C	45
2460		Water Beetle (Laccophilus Maculosis)	Stimulate Movement		1

Salt Water Toxicity

ppm	hrs	species	parm.	cond	ref
85	24	Rainbow Trout	TLm	Constant Alkalinity	46
45	24	Atlantic Salmon	TLm	Constant Alkalinity	46
>1000	96	Sheepshead Minnow	TLm	pH 6.5	426
<250	96	Sheepshead Minnow	TLm	pH 8.2	426

Mammalian

species	mg/kg B. W.	administration route	ref
Rats	30	Intramuscular	8
Guinea Pig	240	Intravenous	47

AMMONIUM CITRATE

SYNONYMS - Diammonium Citrate, Citric Acid Diammonium Salt

Sp. G. - 1.48

SOLUBILITY - Very Soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates to ammonium and citrate ions. Citric acid has a BOD_5 = .42 lb/lb (46% theoretical)(13). Ammonium ion oxidizes to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will result from ammonium ion.

AMMONIUM FLUOBORATE

M.P. - Sublimes

Sp. G. - 1.851

SOLUBILITY - Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates. Ammonium ion is subject to biodegradation after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Will depend on ammonium ion.

AMMONIUM HYDROXIDE

SYNONYMS - Ammonium Hydrate, Aqua Ammonia, Spirit of Hartshorn, Water of Ammonia

COMMON SHIP OR CONTAINER SIZE - 5 pt. glass bottles, 13 gal. carboys, 110 gal. steel drums, tank cars

M.P. 77°C

B.P. Solution only

Sp. G. - 0.90

SOLUBILITY - >1,000,000

PERSISTENCE

Chemical Hydrolysis, etc. - Ammonium hydroxide is a product of the dissolution of ammonia. Its level in water will be determined by the pH and alkalinity of resulting solutions. Hence, natural dilution will neutralize ammonium hydroxide. The ammonium ion is degradable in 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref
17	96	Mosquito Fish	TL_m	Turbid	1
4.5	--	Goldfish	Lethal		1
6.25	24	Trout	Lethal		1
10	--	Suckers, Shiner, Carp, Trout	Lethal		1
11	24	Suckers, Shiner, Carp, Trout	Lethal		1
15	48	Sunfish	TL_m	Phila. Tap Water, 20°	1
17.5	48	Minnow	TL_m		1
18.5	48	Sunfish	TL_m	Phila. Tap Water, 20°	1
20	.2	Suckers, Shiner, Carp, Trout	Lethal		1
40	24	Small Fish	Lethal		1
40	24	Chub	Lethal	15-21°	1
40	--	Perch	Lethal		1

ppm	hrs	Species	Term	Cond.	Ref
60	24	Daphnia	TL_m	Const. Temp	59
32	48	Daphnia	TL_m	Const. Temp	59
20	96	Daphnia	TL_m	Const. Temp	59
12	48	Rana Pipiens, Bullfrogs	Toxic	Field	22

Mammalian Toxicity

Species	mg/Kg B. W.	Administration Route	Ref
Cat	250	Oral	8

AMMONIUM HYPOPHOSPHITE

Sp. G. = 1.401

SOLUBILITY = 227,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Hypophosphite oxidizes to phosphate. Ammonium ion biodegrades to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity depends on ammonium ion.

AMMONIUM IODIDE

M.P. = Sublimes 551°C

B.P. 404.9°C

Sp. G. = 2.514

SOLUBILITY = 1,542,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Ammonium ion will oxidize to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will depend upon ammonium ion.

AMMONIUM NITRATE

Ammonium nitrate is used in fertilizer, explosives, the manufacture of nitrous oxide, herbicides and insecticides, absorbent for nitrogen oxides, freezing mixtures, solid rocket propellants, catalysts, and as a nutrient for antibiotics and yeast. About 13 billion pounds were produced in 1970 in the United States (199). Growth has continued at nine percent per year (198). Ammonium nitrate is shipped in bags, carloads, tank cars, tank trucks, and barges. Because of the explosive nature of dry NH_4NO_3, it is shipped in the form of an aqueous slurry.

Ammonium nitrate is very soluble in water, and will soon dissolve when spilled. Elevation of the solution pH leads to the release of some ammonia gas. Both ammonia and nitrate can provide nitrogen to bacteria and hence act as nutrient sources. Ammonia, in fact, displays an oxygen demand while being converted to nitrate and/or nitrite. This oxygen demand does not occur immediately after entry, but is delayed. Consequently, oxygen sags are not likely to accompany spills. Nitrates can be degraded under anaerobic conditions.

Ammonium nitrate can be toxic to fish. Bluegills have been killed in 1.9 hrs by 800 ppm (1). Test specimens survived 184 hours in a similar concentration when makeup water was distilled (1). The LD50 for Aspergillus niger has been reported as 15 ppm (216). In general, the threshold concentration for fish is .5 ppm free ammonia (41). Solution pH, buffer capacity, and hardness are important in determining resulting toxicity. Because of the nutrient value of ammonium nitrate, spills may cause massive algal blooms in static or slow moving waters.

Ammonium nitrate is an irritation-causing allergen, therefore water for body contact should not contain more than 1.0 ppm free ammonia (40). Drinking water limits of 0.05 ppm have been established for free ammonia (40), but these are based largely on organoleptic considerations.

NAME Ammonium Nitrate

PRODUCTION QUANTITY 11 billion lbs-1971 (199)

SYNONYMS Norway Saltpeter

COMMON SHIP OR CONTAINER SIZE Bags, metal barrels or drums, wooden barrels or kegs, fiber drums, trucks, boxcars, hopper cars

DOT Oxidizing Material, Yellow Label, 100 lbs in an outside container

USCG Oxidizing material, yellow label

M.P. 169.6 °C

B.P. 210 °C slowly decomposes

Sp.G. 1.66

SOLUBILITY 550,000 mg/l at 0 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
800	1.9	Bluegills	Killed	Tap	1
800	104	Bluegills	Killed	Distilled	1
4545	90	Goldfish	Killed	Distilled	1
15	40	Aspergillus Niger	LD50	Temp 10°C	216

AMMONIUM OXALATE

M.P. - Decomposes

Sp. G. - 1.502

SOLUBILITY - 25,400

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates partially in water. Oxalate is biodegradable, BOD$_5$ - 40% theoretical in quiescent conditions. Ammonium ion will oxidize to nitrate after 4-5 days (Ref. 5).

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will depend upon ammonium ion.

AMMONIUM PENTABORATE

Sp. G. - 1.0

SOLUBILITY - 70,100

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Ammonium ion oxidizes to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity depends upon ammonium ion.

AMMONIUM PEROXYDISULFATE

SYNONYMS - Ammonium Persulfate

M.P. 120°C Decomposes

Sp. G. - 1.98

SOLUBILITY - 582,000 mg/l at 0°C

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposes first to $(NH_4)_2S_2O_7$, then to NH_4HSO_4.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond	Ref
120	48	Daphnia	Median Threshold	23°C	1
33	96	Scenedesmus	Median Threshold	24°C	1 (as S_2O_8)
1000		E. coli	No effect	27°C	1 (as S_2O_8)

Mammalian

Species	mg/Kg B. W.	Administration Route	Ref
Rat	820	Oral	8

AMMONIUM SILICOFLUORIDE

SYNONYMS - Ammonium Fluosilicate, Ammonium Hexafluorosilicate,
Cryptohalite

COMMON SHIP OR CONTAINER SIZE - Drums

M.P. - Decomposes at 120°C

Sp. G. - 2.01

SOLUBILITY - 185,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Ammonium ion will oxidize to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
50	48	Tinca vulgaris	Lethal		1

Mammalian Toxicity

Species	mg/kg B.W.	Administration Route	Ref.
Guinea Pig	150	Oral	8
Rat	100	Oral	96

AMMONIUM SULFAMATE

SYNONYMS - Ammate, AMS, Ammonium Amidosulfate

COMMON SHIP OR CONTAINER SIZE - Bags, Carlots, Truck Loads

M.P. 131°C

B.P. 160°C, Decomposes

Sp. G. - ~1.0

SOLUBILITY - 1,666,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates and oxidizes after 4-5 days leaving sulfate and nitrate ions.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Param	Cond.	Ref
259	24	Catfish	TL_m		1
206	48	Catfish	TL_m		1
203	96	Catfish	TL_m		1
76 lb/acre	--	Alligator Weed	1% Control	Field	150
130 lb/acre	--	Cattail	80% Control	Field	150
#16/gallon	--	Frogs	Blinded	Field	1
5	24	Trout, Sunfish		Lake Huron Water	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rat	3900	Oral	96

AMMONIUM SULFIDE

SYNONYMS - Ammonium Monosulfide, Ammonium Polysulfide

Sp.G. - 1.20

SOLUBILITY - Very soluble

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Effect	Cond.	Ref
100	72	Goldfish	Killed	Hard	1
10	100	Goldfish	Survived	Hard	1
240	96	Mosquito Fish	TL_m	Turbid at 21°C	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Mice	2	Oral	1

AMMONIUM SULFITE

M.P. - Sublimes at 150°C and decomposes

Sp.G. - 1.41

SOLUBILITY - 324,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water where oxidation produces sulfate and nitrate ions.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Term	Cond.	Ref
240	24	Mosquito Fish	TL_m	Turbid	1
240	48	Mosquito Fish	TL_m	Turbid	1
240	96	Mosquito Fish	TL_m	Turbid	1

AMMONIUM TARTRATE

SYNONYMS - L-Tartaric Acid, Ammonium Salt

M.P. - Decomposes upon heating

Sp. G. - 1.601

SOLUBILITY - 63,000

PERSISTENCE

Chemical Hydrolysis, etc. - Partially dissociates in water. The tartrate ion should be biodegradable. Ammonium ion oxidizes to nitrate after 4-5 days.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will depend upon ammonium ion.

AMMONIUM THIOCYANATE

Ammonium thiocyanate is commonly used in textile processing, plastics synthesis, the manufacture of mordants and surfactants, as an additive to insecticides, in electroplating, in chemical laboratories, and in the production of matches. It is presently marketed by seven major firms.

Ammonium thiocyanate is freely soluble in water, forming a slightly acidic solution. The thiocyanate anion is subject to attack by chlorine resulting in the release of cyanide ions. This makes it an especially insidious toxin if present in water treatment plant influents. Concentrations in excess of 5000 ppm can inhibit the BOD of sewage (1).

Aquatic life has toxic responses to concentrations ranging from 50-900 ppm (1). A level of 200 ppm was found clearly lethal to freshwater fish (22). Some invertebrates withstood 100 ppm (1) and one researcher found 1600 ppm to be the lethal limit for goldfish and tench in 24 hours (1). Solution pH is critical to the toxicity of this compound. In general, the free ammonia threshold for fish is .5 ppm (41).

Rats have been found to display an oral LD50 of 854 mg/Kg body weight and subcutaneous LD50 of 1000 mg/Kg body weight as potassium thiocyanate(8). The potassium salt is believed to be representative of its ammonia analogue. Livestock and porcupines are repelled by this compound (22). Free ammonia should be maintained below .05 ppm for drinking water and 1 ppm for body contact exposure (40).

NAME Ammonium Thiocyanate

SYNONYMS Ammonium Rhodanide, Ammonium Sulfocyanate, Ammonium Sulfocyanide

M.P. 149.6 °C

B.P. 170°C Decomposes

Sp.G. 1.310

SOLUBILITY 1,280,000 mg/l at 0°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	harm	cond	ref
280-300	1	Orange Spotted Sunfish	Killed		1
200		Fish	Deadly		1
114	96	Mosquito Fish	Tlm	Turbid Water at 16-23 °C	1
910	24	Mosquito Fish	Tlm	Turbid Water 16-23°C	1
420	48	Mosquito Fish	Tlm	Turbid Water 16-23°C	1
1600	24	Goldfish & Tench	Lethal Limit		1
50		Chironomous Larvae	Killed		1
100		Carcinogamma-rus & Asellus Aquaticus	No Harm		1
200		Fish	Lethal		22

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	854	Orally as Potassium Salt	8
Rat	1,000	Subcutaneous as Potassium Salt	9
Rat	500	Intraperitoneal	86

AMMONIUM THIOSULFATE

SYNONYMS - Ammonium Hyposulfide

M.P. - Decomposes at 150°C

SOLUBILITY - Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates and oxidizes to sulfate and nitrate in time.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity depends upon ammonium ion.

AMYL ACETATE

Amyl acetate, or pear oil, is used extensively in organic chemical industries, varnishes, lacquers, and dyeing. Approximately 11 million lbs were produced in 1971. (198)

Amyl acetate is a light oil of very limited solubility. When spilled, it will form a colorless slick on the surface of the water and exude a sweet pear-like odor. That material which does dissolve is biodegradable with .1-8 lbs of oxygen being consumed per lb of oil in 5 days(11). The limited solubility, however, will prevent massive oxygen deficiencies from occurring.

Amyl Acetate is toxic to fish when present in the 50-100 ppm range. While chub tolerated 40 ppm for 24 hours, they all died in water with 120 ppm of the oil (1). Wallen, et. al., found no deviation in the 65 ppm Tlm values for mosquito fish during 24, 48 and 96 hour exposure times (1). Invertebrates showed similar responses to 120-180 ppm (1). E. Coli, however, was able to withstand 1000 mg/l with no visible toxic effects(1). In saltwater, the 24 hour Tlm for brine shrimp is 53 ppm (425).

Amyl acetate can cause acute irritation but is not considered an ingestive toxin. Inhalation limits revolve around a TLV of 525 mg/m^3. As a light insoluble oil, amyl acetate poses a threat to waterfowl and marine mammals. Threshold odor levels fall in the range .0017-.86 ppm (30), while amyl acetate can be tasted at .0006 ppm in water (4).

NAME Amyl Acetate

PRODUCTION QUANTITY 11 million lbs 1971 (198)

SYNONYMS 1-Pentanol Acetate, Amyl Acetic Ether, Pear Oil

DOT Flammable Liquid, Red Label, 10 gal in outside container

USCG Inflammable liquid, red label

M.P. -78.0°C

B.P. 149.0 °C

Sp.G. 0.88

SOLUBILITY 820 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = .3-.8 lb/lb using sewage seed-(11)
BOD_5 = 38% Theo.-(18)
$BOD_{5,10,15,20}$ = 64, 76, 67, 72% Theo. in fresh water (425).
$BOD_{5,10,15,20}$ = 35, 65, 69, 87% Theo. in salt water (425).

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	meas	cond	ref
120		Chub	Died	Aerated 15-21°C	1
65	24	Mosquito Fish	TLm	Turbid	1
65	48	Mosquito Fish	TLm	Turbid	1
65	96	Mosquito Fish	TLm	Turbid	1
120	48	Daphnia	TLm	23°C	1
180	96	Scenedesmus	TLm	24°C	1
1,000		E. Coli	No Effect	27°C	1

Salt Water Toxicity

ppm	hrs	species	meas	cond	ref
51	24	Brine Shrimp	TLm		425

ANILINE

Aniline is used in making dyes, vulcanizing rubber, producing resins and shoeblack solvent, and manufacturing medicinals, varnishes and perfumes. The .3 million lbs produced in 1969 (199) were shipped by truck, rail, and barge. Containers range from one pound bottles to 55 gal. metal drums to tank cars.

Aniline is soluble in water to 35,000 ppm. When spilled it will seek the bottom and slowly dissolve. Pure aniline darkens when exposed to air and light. Presence of acids leads to formation of associated salts. If solutions are chlorinated, chloroanilines are first formed and then p-benzoquinone develops. The dissolved aniline is readily attacked by bacteria. As much as 1.5-2.26 lbs of oxygen per lb of aniline may be utilized in the first 5 days with exposure to sewage seed (11). This rate may be sufficient to cause localized oxygen sags in spill situations.

Aniline is toxic to fish and fish food organisms. Various species of fish have been reported killed by concentrations in the range 100-1020 ppm with the latter causing death in 1 hr (1). The 48 hr TLm for Daphnia has been given as .4 ppm while the 96 hr value for Scenedesmus is 10 ppm (1).

Aniline is highly toxic by all routes of administration. The average oral LD50 for mammals is 400-499 mg/Kg body weight (8). Serious poisoning in humans has resulted from consumption of .25 ml (1). The maximum allowable concentration in drinking water is given as 5 ppm (1). Aniline can be absorbed through the skin. Water in which prolonged body contact may occur should not contain more than 50 ppm (7). The chronic oral threshold for rats is reported to be greater than .005 mg/Kg/day (15). When rats were fed 1.1 percent in synthetic diets (10-65 mg/Kg body weight/day) 4 of 12 subjects developed tumors (15). Similar tests at .1 percent for 224 days resulted in tumors in 2 of 10 test animals (15).

NAME Aniline

PRODUCTION QUANTITY .3 million lbs 1969

COMMON SHIP OR CONTAINER SIZE 1 lb bottles, 10 gal metal cans,
drums up to 55 gal, tank cars,
tank trucks

DOT (aniline oil liquid) Class B Poison, Poison Label, 55 gal in outside container

USCG Combustible liquid, Class B poison

M.P. -6.0 °C

B.P. 184 °C

Sp.G. 1.022

SOLUBILITY 35,000 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = 1.5-2.26 lb/lb using sewage seed-(11)
COD = 2.4 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
100		Trout	Killed		1
200		Minnow	Killed		1
1000		Goldfish	Killed		1
1020	1	Sunfish	Killed		1
250	Unspecified	Fish	Killed		1
279	Prolonged	Daphnia	Immobilized	Lake Erie	1
0.4	48	Daphnia	TLm	21°	1
10	96	Scenedesmus	TLm	24°	1
1000		E. Coli	TLm	27°	1
1000	96	Bluegill	LC_{50}		430

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	500	Oral	1
Mammals	400-499	Oral	15
Rat	750	Oral	15
Mouse	1075	Oral	15
Guinea Pig	1290	Dermal	29

ANTIMONY PENTACHLORIDE

Antimony pentachloride is a colorless to yellow fuming liquid used as a catalyst in organic synthesis. It decomposes when spilled in water to form sparingly soluble Sb_2O_5 and HCl. Toxicity is a result of the antimony metal itself. The oral LD_{50} for rats is reported as 675 mg/kg body weight.[8]

Antimony can be concentrated by a factor of 300 by marine life.[1] It is toxic to man when present in water at 25 ppm. The Soviet Union has set a drinking water limit of 0.05 ppm Sb or less.[11]

ANTIMONY PENTACHLORIDE

SYNONYMS - Antimonic Chloride, Antimony Perchloride

DOT - Corrosive liquid, white label, 1 quart outside container

USCG - Corrosive liquid, white label

M.P. 2.8°C

B.P. 140°C

Sp. G. - 2.336

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Hydrolyses in water to form Sb_2O_5 and HCl. Antimony pentoxide is only slightly soluble.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will result from toxic antimony metal.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	675	Oral	1

ANTIMONY PENTAFLUORIDE

Antimony pentafluoride is a corrosive, hygroscopic liquid. It is employed in the fluorination of organic compounds. Antimony pentafluoride reacts vigorously when spilled in water, producing a clear solution. With dilution, most antimony will be precipitated. Toxicity results from the presence of antimony metal itself. The pentafluoride is corrosive to skin.

Antimony can be concentrated by a factor of 300 by marine life.[1] It is toxic to man when concentrated in water at 25 ppm. The Soviet Union limits drinking water to 0.05 ppm Sb or less.[33]

ANTIMONY PENTAFLUORIDE

SYNONYMS - Antimony Fluoride

DOT - Corrosive liquid, white label, 25 pounds in an outside container

USCG - Corrosive liquid, white label

M.P. 71°C

B.P. 149.5°C

Sp.G. - 2.99

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Reacts violently in water to produce clear solution.

TOXICOLOGICAL

Fresh Water Toxicity - Toxicity results from corrosive action and the presence of Fluoride.

Salt Water Toxicity - Toxicity results from presence of antimony metal.

ANTIMONY POTASSIUM TARTRATE

Antimony potassium tartrate, or tartar emetic, is used as a mordant, as a bait for ant and thrip control, and as a medicinal in veterinary activities. It is presently marketed by seven major firms.

Tartar emetic is of limited solubility. It is most likely to sink if spilled in water and then slowly dissolve. The antimony-tartrate portion of the salt is in fact an ionic complex. The tartrate serves to shield the antimony from agents which might otherwise precipitate it. Phosphates can join this complex forming a blue super-complex familiar to analytical chemists as a spectrophotometric phosphate measurement technique.

Tartar emetic has been found to be toxic to aquatic life in the 1-20 ppm range as Sb. Fathead minnows tolerated more antimony in hard water than soft with the 96 hr TLm dropping from 20 to 12 ppm (1).

Invertebrates were inhibited at levels of 1.5-9 ppm as Sb (1). Green algae was inhibited by 1.5 ppm as Sb. E. Coli was found to have a median toxic threshold of 11 ppm as Sb. Marine life can concentrate antimony by a factor of 300 (1).

A wealth of information is available on the effects of direct ingestion of tartar emetic. Oral LD50 values of 300-600 mg/kg body weight have been reported (1,8). Humans can die from ingestion of 150 mg (1). Daily doses of 20 mg were sufficient to limit growth in rats, while a single dose of 115 mg/Kg body weight was fatal to rabits in 24-72 hrs (1). Rats fed up to 100 mg/Kg body weight daily developed normally, but experienced heart injury (1). Horses can take doses of 5.0 grams and cattle 1.0 grams thrice daily without harm.

Tartar emetic has been replaced by less toxic antimony compounds as a treatment for tropical parasites due to a frequency of toxic reactions. These are largely evidenced as heart difficulties. It has been reported that 25 ppm of antimony in drinking water can be hazardous to man. The Soviet Union places a limit of .05 ppm Sb in drinking water (58).

NAME Antimony Potassium Tartrate

SYNONYMS Tartar Emetic, Potassium antimony Tartrate, Tartarized Antimony

COMMON SHIP OR CONTAINER SIZE Drums and Barrels

M.P. 100 °C loses H_2O

Sp. G. 2.6

SOLUBILITY 8,300 mg/l @ 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
20	96	Fathead Minnows	TLm	Soft	1 (as Sb)
17	96	Fathead Minnows	TLm	Hard	1 (as Sb)
15	-	Protozoa	inhibits food intake	-	1
3.5	-	Green Algae	inhibits cell division	-	1
9	-	Daphnia	inhibits movement	-	1 (as Sb)
5	24	Sea Lamprey	No effect	Lake Huron	1
3.5	96	Scenedesmus	Med. toxic threshold	24°	1 (as Sb)
33	-	E Coli	Med. toxic threshold	27°	1 (as Sb)

Mammalian

species	mg/kg B.W.	administration route	ref
Mice	50	Intraperitoneal	8
Mice	600	Oral	8
Rat	300	Oral	1

ANTIMONY TRIBROMIDE

Antimony tribromide is a solid which decomposes in water to form antimony oxybromide and HBr. Dilution will result in the ultimate precipitation of the antimony. Antimony tribromide is considered toxic to aquatic life as a result of its ability to release antimony ions to the water column.

Antimony can be concentrated by a factor of 100 by marine life.[1] It is toxic to man when present in water at 25 ppm and has been limited to 0.05 ppm or less for drinking water purposes in the Soviet Union.[11]

ANTIMONY TRIBROMIDE

SYNONYMS - Antimony Bromide, Antimonous Bromide

M.P. 96.6°C

B.P. 275°C

Sp. G. - 4.148

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposed by water, light or alcohol. Hydrolysis leads to the oxybromide salt SbOBr and HBr.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will result from antimony.

ANTIMONY TRICHLORIDE

Antimony trichloride is commonly shipped in metal drums and pails and boxed glass carboys. The quantity produced by eight major firms in 1972 was used for mordants, for the production of chemicals, and in chemical laboratories.

Antimony trichloride hydrolyses upon contact with water to form hydrochloric acid and soluble oxychlorides such as SbOCl and $Sb_4O_5Cl_2$. Upon dilution, these salts precipitate out. In a spill situation, the fate of the antimony will depend largely on the alkalinity and pH of the receiving water, and the strength of dispersion forces within the body. A precipitate can be expected with time.

Antimony trichloride is reported to be toxic to fish at the 9-17 ppm as Sb level (1). Experiments showed hard water TLm values to be nearly twice those for soft water (1). Trout, bluegills, and sea lampreys were not affected at 5 ppm but 11 ppm is considered the threshold for immobilization of Dapnia in Lake Erie(1). Antimony can be concentrated by a factor of 300 by marine life (1).

Median lethal doses of 675 and 574 mg/kg body weight have been reported for antimony trichloride fed to rats and guinea pigs, respectively (57,58). This irritant has been implicated in the poisoning of people. Concentrations of 25 ppm Sb in water poses a hazard to man. The Soviet Union limits drinking water to .05 ppm Sb or less (58).

In the absence of the antimony, chlorides should not exceed 3000 ppm for use with livestock and 500 ppm for irrigation of citrus fruits (41).

NAME Antimony Trichloride

SYNONYMS Butter of Antimony, Antimony Chloride, Caustic Antimony

COMMON SHIP OR CONTAINER SIZE Metal drums and pails, glass carboys

M.P. 73.4 °C

B.P. 283.0 °C

Sp.G. 3.14

SOLUBILITY 6,020,000 mg/l at 0°C

PERSISTENCE

Chemical Hydrolysis, etc.

Hydrolyses to form hydrochloric acid and soluble SbOCl, $Sb_4O_5Cl_2$, etc. which precipitate out upon dilution.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
17		Daphnia	Immobilized Threshold	Lake Erie 25°C	1
9	96	Fathead Minnow	TLm	Soft	(as Sb) 1
17	96	Fathead Minnow	TLm	Hard	(as Sb) 1
5	24	Rainbow trout, Bluegill, & Sea Lamprey	No Effect	Lake Huron pH 7.5-8.2, 13°C, Sat O_2	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	675	Oral	57
Guinea Pig	574	Oral	16

ANTIMONY TRIFLUORIDE

Antimony trifluoride for textile drying, chemical preparations, and pottery porcelains is generally stored in glass vessels or steel drums. It is marketed by seven major firms in the U.S.

Antimony trifluoride undergoes limited hydrolysis as it dissolves in water forming SbOF and HF as products. Once dissolved, the antimony readily forms complexes such as $[SbF_4]^-$ and soluble salts. Dilution may ultimately lead to precipitation of antimony trioxide and possibly calcium fluoride in natural waters.

A concentration of 200 ppm killed fish (Tinca vulgaris) in less than 24 hrs (1). Toxic effects vary with solution pH. In general, the threshold for fresh and saltwater fish is 1.5 ppm fluoride (41). Antimony can be concentrated by a factor of 100 by marine life (1).

A median lethal dose of 100 mg/Kg body weight has been reported for guinea pigs (1). Concentrations of 25 ppm Sb in drinking water pose a hazard to man. The Soviet Union recommends a limit of .05 ppm Sb in drinking water (56). On the basis of fluoride content only drinking water should be limited to .6 ppm (7), livestock water to 1 ppm (41), and irrigation water for vegetables to 5 ppm (41).

NAME Antimony Trifluoride

SYNONYMS Antimony Fluoride, Antimonous Fluoride

COMMON SHIP OR CONTAINER SIZE Glass vessels, steel drums

M.P. 292.0 °C

B.P. 319.0 Sublimes

Sp.G. 4.38

SOLUBILITY 4,430,000 mg/l at 30°C

PERSISTENCE

Chemical Hydrolysis, etc.

Limited hydrolysis to SbOF + HF - ready formation of SbF_4^- complexes

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	effect	cond	ref
200	<24	Tinca Vulgaris	Killed		1

Mammalian

species	mg/kg B. W.	administration route	ref
Guinea Pig	100	Oral	1

ANTIMONY TRIOXIDE

Antimony trioxide, a pigment, fire retardant, and mordant, was produced at a level of 6,000 tons in 1970. (107) Production is projected to double in 1973. It is shipped in barrels, trucks, and railroad cars as a basically insoluble solid.

Antimony trioxide is of limited solubility. As solution pH rises, less antimony remains in a dissolved state. Tartrates and halides are capable of forming soluble complexes.

Exploratory testing showed the 96 hr TLm for fathead minnows to be greater than 80 ppm (1). Antimony can be concentrated by marine life as much as 300 times (1).

The median lethal dose to rats is reported as greater than 20 grams/Kg body weight (8). Single doses of 2-3 grams have no apparent effects on rats. Chronic feeding of 2 percent in food, however, reduced growth rates in rats and rabbits (1). Daily doses of 150 mg/Kg body weight for four weeks was harmless to rabbits (1). Concentrations of 25 ppm Sb in water are considered hazardous to man. The Soviet Union recommends drinking water limits of .05 ppm Sb (58).

NAME Antimony Trioxide

PRODUCTION QUANTITY 6,000 tons 1970 (197)

SYNONYMS Diantimony Trioxide, Flowers of Antimony, Weisspiessglanz, Senarmontite, Valentinite, Exitelite, Antimony Oxide

COMMON SHIP OR CONTAINER SIZE Barrels, trucks, railroad cars

M.P. 655. °C

B.P. 1425. °C Sublimes

Sp.G. 5.20

SOLUBILITY <50,000 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
>80	96	Fathead Minnow	TLm	Hard or Soft	as SB 1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	>20,000	Oral	8

ARSENIC

Arsenic is found widely in nature in conjunction with the ores of such other metals as copper, lead, zinc, and tin. In its natural state, arsenic is typically combined as an arsenide of a true metal, or a pyrite. Arsenic is used in metallurgy to increase hardening and heat resistance, in glassware and ceramics, in xerography, as an agent for tanning and wood preservation, and in the production of various chemicals and pesticides. Common salts in industry include sodium, lead, and calcium arsenate; sodium arsenite; arsenous acid; and arsenic triselenide. These compounds are solids.

While elemental arsenic is insoluble in water, arsenates and other salts are generally quite soluble. Spillage of these compounds will result in fairly rapid dissolution. In the aquatic environment, the arsenate ion will predominate under aerobic conditions, and the arsenite under reducing conditions. Arsenates have been identified in many natural waters (56). Calcium arsenate is soluble to only 48 ppm. Consequently, in many natural waters, residual calcium will lower arsenate levels by forming an insoluble bottom deposit. Similar transport downward will be associated with sorption onto iron particles. Precipitated arsenic is subject to methylation with the production of arsine.

This gaseous specie then rises back into the water column. Subsequent oxidation returns the arsenic to the arsenate form and begins the cycle over again. This process can continue indefinitely with the arsenic changing form and location in the water column until consumed by a higher order organism (181). Concentrations greater than 100 ppm can inhibit oxygen uptake by sewage organisms.

Arsenic is quite toxic to fish forms in the concentration range 1.1-60 ppm (1). Concentrations of 3.1 ppm, 4.3 ppm, and 7.6 ppm have been fatal to carp, crabs, and bass, respectively, after several days of observation. Lower organisms appear more resistant, with mayfly nymphs, and dragon and damsel flies tolerating .3-14 mg/l and 10-20 mg/l, respectively (1). Arsenic trioxide on the other hand destroys fish food organisms in the range 2-4 ppm (1). Higher organisms are similarly affected (1). In general, 1 ppm is considered the threshold concentration for fresh and saltwater fishes (41). Arsenic is concentrated to a limited extent in the aquatic food chain as evidenced by the build-up of arsenic-76 from nuclear reactor effluents.(1) Aquatic plants should not be exposed to levels of more than 1 ppm (1).

Arsenic poses an extreme ingestive hazard to man and other mammals. The oral LD50 for the rat is reported to be 112 mg/kg body weight (1). Pigs and fowl have died from consumption of 6.5 mg/oz. (1). A dose of 130 mg arsenic can be fatal to humans. Chronic consumption of water containing as little as 0.21 mg/l has proven poisonous (1). Present drinking water limits require less than .01 ppm arsenic (49). Water for livestock should not exceed 0.5 ppm (42) and for waterfowl, 1.0 ppm (1).

Arsenic in water has been correlated with the occurrence of blackfoot disease in Taiwan (294). Arsenic has also long been suspected as a causal factor for Haff's disease (1). Arsenic is the single proven example of a carcinogen acting through the drinking water medium. (181)

Arsenic may be quite toxic to plants if present at excessive levels in a soluble form. Initial effects are seen in reduced yields. Beans and cucumbers are especially sensitive. Orchard soils in the State of Washington with 4-12 mg arsenic/kg have been reported as unproductive (1). Water for irrigation should be limited to .1 ppm or less (41).

ARSENIC ACID

SYNONYMS - Orthoarsenic Acid

COMMON SHIP OR CONTAINER SIZE - Glass bottles, barrels

DOT - Poison B, poison label, 55 gallon in an outside container

USCG - Poison B, poison label

M.P. 35.5°C

B.P. - Loses water at 160°C

Sp. G. - 2.0 - 2.5

SOLUBILITY - 167,000

PERSISTENCE

Chemical Hydrolysis, etc. - Arsenicals eventually are precipitated as calcium arsenate. Biological action in the sediments may then release arsine which rises in the water column, is oxidized to arsenate, and thus returns to the sediment completing the cycle.[1,7]

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will result from the arsenic metal.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rabbit	8	Intravenous	8

ARSENIC DISULFIDE

SYNONYMS - Red Arsenic Sulfide, Realgar, Red Orpiment, Ruby Arsenic, Red Arsenic Glass, Arsenic Bisulfide, Arsenic Monosulfide

COMMON SHIP OR CONTAINER SIZE - Steel drums

DOT - Poison B, poison label

USCG - Poison B, poison label

M.P. 307°C

B.P. 565°C

Sp. G. - 3.4 - 3.6

SOLUBILITY - Practically insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Will oxidize with time.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is estimated as a function of the arsenic metal content.

ARSENIC PENTOXIDE

SYNONYMS - Arsenic Acid Anhydride, Arsenic Oxide

COMMON SHIP OR CONTAINER SIZE - Drums, cartons, boxes, tins

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

M.P. 315°C decomposes

Sp. G. - 4.086

SOLUBILITY - 1,500,000

PERSISTENCE

Chemical Hydrolysis, etc. - Combines very slowly with water to form H_3AsO_4. Arsenate will precipitate as the calcium salt and enter a biological-chemical cycle involving arsenate and arsine forms (181).

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for arsenate anion.

Mammalian Toxicity

Species	mg/Kg B. W.	Administration Route	Ref
Rat	8	Oral	8

ARSENIC TRICHLORIDE

SYNONYMS - Butter of Arsenic, Fuming Liquid Arsenic.

COMMON SHIP OR CONTAINER SIZE - Bottles, 20-55 gallon drums

DOT - Poison B, poison label, 55 gallons in an outside container

USCG - Poison B, poison label

M.P. 18°C

B.P. 130.2°C

Sp. G. - 2.163

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Hydrolyses in water forming As_2O_3 and HCl.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for As_2O_3.

ARSENIC TRIOXIDE

SYNONYMS - White arsenic, Arsenious Acid, Arsenious Oxide, Arsenous Anhydride

COMMON SHIP OR CONTAINER SIZE - 5-50 gal. drums, barrels, carloads

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

M.P. 193°C, Sublimes

Sp. G. - 3.865

SOLUBILITY - 1200

PERSISTENCE

Chemical Hydrolysis, etc. - Will slowly be precipitated as calcium arsenate.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref
1.96	--	Chironomus	Harmful	--	1
2-3	--	Fish Food Organisms	Harmful	--	1
2.5	--	Fish Food Organisms	Harmful	--	1
2.5-4	--	Fish Food Organisms	Harmful	--	1
5.3	192	Pink Salmon	Harmful	--	1
10	--	Fish	Harmful	--	1
10	240	Bass	Harmful	--	1
10	--	Bass, Bluegill Crappies	Harmful	--	1
16	72-504	Mussels	Harmful	--	1
40	--	Flatworms	Harmful	--	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Human	100-Low Lethal Dose	Oral	90
Human	0.5 mg/m³ - Low Toxic Concentration	Inhalation	90
Rat	45	Oral	90

ARSENIC TRISULFIDE

SYNONYMS - Yellow Arsenic Sulfide, Arsenious Sulfide, Arsenous Sulfide, Arsenic Tersulfide, Orpiment, Auripigment, King's Yellow, King's Gold

DOT - Poison B, poison label

USCG - Poison B, poison label

M.P. 300°C

B.P. 707°C

Sp. G. = 3.43

SOLUBILITY = 0.5

PERSISTENCE

Chemical Hydrolysis, etc. - Subject to slow oxidation.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is related to arsenic content.

CALCIUM ARSENATE

Calcium arsenate is a white amorphous powder employed as a rodenticide, molluscicide, and insecticide. It is particularly effective in the latter capacity against insects destructive to plants.

Calcium arsenate is soluble to 130 mg/l in water. Solubility increases with acidity. As one of the least soluble arsenate salts, calcium arsenate spills ultimately lead to a buildup of arsenate in nearby sediments. Biological action can subsequently solubilize arsenic in the form of arsine compounds. These, in turn, can be oxidized back to arsenate and precipitated, thus, closing the cycle.[18]

Arsenate compounds are reported to be less toxic than trivalent or other salt forms.[18] Thus, sodium arsenate is much less toxic than sodium arsenite or arsenic trioxide.[1] Since forms can have their valency altered, however, arsenic toxicity in general is of interest. Arsenic in general has been found to be quite toxic to aquatic life. Perch exposed for 48 hours showed toxic reactions to 1.1 mg/l as did carp exposed for 96 hours to 1.1 mg/l and crabs exposed to 50 ppm for 16 hours.[1] It is recommended that salt or fresh water be limited to less than 1 mg/l As if aquatic life is to be propagated.[11] Similarly, water for aquatic plants and waterfowl should not exceed 1 ppm.[1] Arsenic is concentrated to a limited extent in the aquatic food chain.[1]

Calcium arsenate is a highly toxic irritant and allergen. The oral LD_{50} for rats is reported to be 298 mg/kg body weight.[11] Drinking water limits have been established at .05 mg/l As.[1] The hazards associated with calcium arsenate are those resulting from the arsenate anion and, therefore, are discussed in more detail in the profile on arsenic.

CALCIUM ARSENATE

SYNONYMS - Tricalcium Arsenate, Calcium Orthoarsenate, Pencal

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

SOLUBILITY - 130

PERSISTENCE

Chemical, Hydrolysis, etc. - Arsenate is resolubilized by biological action through the formation of arsines. These forms are subsequently oxidized in the water column and returned to the sediments.[19]

TOXICOLOGICAL

Freshwater Toxicity - Arsenic in general.

ppm	hrs	Species	Parm.	Cond.	Ref
1.1	48	Perch	Toxic	--	1
2.2	72	Bleak	Toxic	--	1
3.1	96	Carp	Toxic	--	1
3.1	72	Roie	Toxic	--	1
7.6	240	Bass	Toxic	--	1
11.6	36	Minnows	Toxic	--	1
60	16	Minnows	Toxic	--	1

Salt Water Toxicity

ppm	hrs	Species	Parm.	Cond.	Ref
4.3	264	Crabs	Toxic	--	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rat	298	Oral	96

CALCIUM ARSENITE

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

SOLUBILITY - Insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Arsenite will oxidize to arsenate under aerobic conditions and enter the arsenate-arsine biological-chemical cycle.

TOXICOLOGICAL

Freshwater Toxicity - Arsenite is a more toxic form of arsenic than arsenate.

POTASSIUM ARSENATE

SYNONYMS - Potassium Acid Arsenate, Potassium Dihydrogen Arsenate, Macquer's Salt, Potassium Orthoarsenate

DOT - Class B Poison, Poison label, 200 lbs in an outside container

M.P. 288°C

Sp. G. 2.867

SOLUBILITY - 188,700 ppm in cold water

PERSISTENCE

Chemical hydrolysis, etc. - Dissociates on dissolution. Arsenate will precipitate as calcium salt and enter chemical-biological cycling mechanism.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the arsenate ion.

Potassium Arsenate

Potassium arsenate is presently produced by two major suppliers for use in textiles, tanning, and paper industries. It may also be used in insecticidal formulations.

Potassium arsenate is soluble to 188,700 ppm in cold water. It dissociates on dissolution. The arsenate anion is soon precipitated as a calcium salt. Subsequent biological action may resolubilize it as arsine which in turn is oxidized and precipitated. This closes the cycle.(1)

Aquatic toxicity will be based on that of the arsenate ion.

Potassium Arsenite

Potassium arsenite is a material of variable composition used to reduce silver salt to metallic silver during mirror silvering. It is a white, hygroscopic powder which gradually decomposes on on exposure to air. In water, the arsenite will oxidize to arsenate and enter the chemical-biological arsenic cycle.(8) The aquatic toxicity of potassium arsenite stems from the arsenite anion.

Potassium arsenite is toxic to mammals. The oral LD_{50} to rats has been reported as 14 mg/kg body weight for the $KAsO_2 \cdot HAsO_2$ salt[9] and 1140 mg/kg body weight as the $HKAsO_3 \cdot K\,AsO_3$ salt.[11]

Potassium Arsenite

DOT - Class B Poison, Poison label, 200 lbs in an outside container

SOLUBILITY - Soluble in cold water

PERSISTENCE

Chemical hydrolysis, etc. - Dissociates on dissolution. Arsenite oxidizes to arsenate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for arsenite ion.

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	14	Oral	8
Rat	1140	Oral	97
Mouse	1200	Skin-LD Low	98

SODIUM ARSENATE

Sodium arsenate is used as an insecticide and is employed for manufacturing printing inks, dyeing and tinting textiles, and producing other chemicals. Pesticide usage has declined greatly in the last few years. Sodium arsenate is presently marketed by six American firms.

Sodium arsenate is quite soluble, and will disperse into receiving waters soon after being spilled. Both the anion and cation are chemically stable and can persist indefinitely. The arsenite anion may be formed if slightly reducing conditions exist. Calcium arsenate is only soluble to 48 ppm. Consequently, most natural waters will have sufficient calcium content to precipitate most of the arsenate out. This insoluble salt will remain on the bottom as a continuous source of low level amounts of arsenate. Arsenic may also reach the bottom sorbed into iron salts. Precipitated arsenic can be methylated by bacteria to an arsine form which is soluble enough to rise back into the water column. Subsequent oxidation leads to a cycling action with the arsenic changing forms and location in the water column(181). Concentrations greater than 100 ppm can inhibit oxygen uptake of sewage organisms.

Sodium arsenate is toxic to fish and fish food organisms. The lethal concentration for minnows has been reported as 234 mg/l. Other sources claim minnows withstand 150 mg/l as arsenic (1). Daphnia are immobilized by the presence of 10-11 ppm (1). Sodium arsenate has been added to ponds at 5 ppm for algae control with no subsequent effect on fish. Arsenic in general should be kept below .1 ppm for fresh and saltwater fish (41). Aquatic plants are not harmed at concentrations below 1 ppm (1). Arsenic is concentrated to a limited extent by aquatic life. Marine plants in seawater containing .05-5 µg/l arsenic have been analyzed to hold 1-12 mg/Kg dry weight. Nearby marine animals contained 0.1-50 mg/Kg. Arsenic can be present in lobsters and shrimp, probably as trimethylarsine, at concentrations as high as 200 mg/Kg. Freshwater species do not concentrate arsenic to the same extent as their marine counterparts (101).

Sodium arsenate can be highly toxic when ingested or inhaled (38). The minimum lethal intraperitoneal dose for rats is 50 mg/Kg body weight (8). The oral LD50 for rats fed arsenate is 110 mg/Kg (56). Chronic poisoning is of greater concern in most cases since mammals accumulate arsenic readily. Rats have shown toxic effects from a two year feeding program using 250 ppm as arsenic (102). A one year program with dogs showed mortality began at 125 ppm as arsenic (102). Humans should not consume more than 1.5 mg/Kg body weight,(1) and drinking water should not contain more than .01 ppm arsenic (49). Water for livestock should not include more than .05 ppm (42) and waterfowl may be affected by waters containing more than 1 ppm (1). No specific carcinogenic properties have been ascribed to arsenic after chronic feeding studies; however, Neubauer claims a positive correlation, and Hueper reports arsenic in drinking water is a classic example of a carcinogenic contaminant (101).

Plants can also be harmed from dissolved arsenic forms. Beans and cucumbers are extremely sensitive (1), the basic threshold for arsenic in irrigation water being 1 ppm (41).

NAME Sodium Arsenate

DOT Poison B, Poison Label, 200 lbs in an outside container

USCG Poison B, poison label

M.P. 86.3 °C

Sp.G. 1.76

SOLUBILITY 389,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, etc.

Calcium arsenate is insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
234		Minnows	Lethal Conc.	16-20°C	1
250 as As	16	Minnows	Survived		1
10-31		Daphnia Magna	Immobilized	Erie	1
670 as AsO_4		Polycelis Nigra	Toxic Threshold		1
2970 as AsO_4	3.3	Phoxinus Phoxinus	Equilibrium Loss	Tap	179
820 as AsO_4	7.6	Phoxinus Phoxinus	Equilibrium Loss	Tap	179
234 as AsO_4	15	Phoxinus Phoxinus	Equilibrium Loss	Tap	179
28	168	Goldfish	TLm		445

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	50	Intraperitoneal-MLD	8
Mice	9	Intraperitoneal	180
Rat	14.7	Intraperitoneal	85
Rat	218	Oral-arsenate	56

Sodium Arsenite

Sodium arsenite is produced in a technical grade, 90-95 percent pure, and used in the manufacture of arsenical soap. It is also employed to treat vines against scale, control termites, and as a topical insecticide against ticks of ruminants. It is shipped both as a solid and in solution in barrels never exceeding 55 gal. in volume.

Sodium arsenite is a white or grayish white powder very soluble in water. It absorbs CO_2 from air and is somewhat hygroscopic. In water, it will oxidize to the more stable arsenate form which precipitates as the calcium salt. At that point, the arsenic enters a biological-chemical cycle between the water and sediment.(8)

Sodium arsenite is more toxic to aquatic life than the arsenate salt. The 96 hour LC_{50} for bluegill, rainbow trout, and goldfish have been reported as 15 ppm, 25 ppm, and 14 ppm respectively.(7) Fish food organisms may be similarly affected. The 48 hour EC_{50} for P. californicas, Daphnia pulex, and Simocephalus serrulatus are 80 ppm, 1.8 ppm, and 1.4 ppm respectively.(7) At earlier stages, toxicity is more acute. The 96 hour LC_{50} for P. californicas naiads is 0.038 ppm.(7)

Sodium arsenite, like all forms of arsenic, is toxic to mammals when taken orally. The oral LD_{50} for rats is 41 mg/kg body weight.(2) Arsenic is also suspected of carcinogenic activity.

SODIUM ARSENITE

SYNONYMS - Sodium meta Arsenite

CARGO SHIP OR CONTAINER SIZE - Up to 55 gal. steel drums

DOT - Class B Poison, Poison label, 55 gallons in an outside container

USCG - Poison B (Solution), Poison label

IATA - (Solid) Poison B, Poison label 25 kg passenger 95 kg cargo;
(Solution) 1 liter passenger, 220 liters cargo

Sp. G. - 1.87

SOLUBILITY - Very soluble in cold waters

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates on dissolution. Arsenite may be oxidized to arsenate and precipitated.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	[illegible]	Cond	Ref.
3.0	-	Caenis sp	Lethal		402
4.0	-	Callibaetis sp	Lethal		402
14.0	-	Libellula sp	90% Survival		402
11.2	-	Ischnura verticalis	95% Survival		402
[illegible]	-	Chironomidae	93% Survival		402
21	-	Asellus communis	91% Survival		402
10.5	-	Hydracarina sp	94% Survival		402
[illegible]	-	Hyalella knickerbockeri	90% Survival		402
[illegible]	-	Colpidium sp	100% Survival		402
[illegible]	-	Paramecium sp, Stylonichia sp, [illegible]	Plasmolysis but no kill		402
0.1	-	Daphnia magna	Immobilization	Lake Erie	402
[illegible]	24	Spottail Shiner	TLm		402
[illegible]	48	Spottail Shiner	TLm		402
[illegible]	72	Spottail Shiner	TLm		402
[illegible]	24	Channel catfish	Lethal	Tap	402
[illegible]	96	Rainbow Trout	Est. LC50	55-75°F	402
[illegible]	96	Bluegill	Est. LC50	55-75°F	402
[illegible]	96	Rainbow Trout	TLm		402
[illegible]	96	Goldfish	TLm		402
[illegible]	96	Bluegill	TLm		402
[illegible]		Daphnia magna	LC50 Immobilization		402
[illegible]		Rainbow Trout	LC50		402
[illegible]		Bluegill	LC50		402
[illegible]	48	Rainbow Trout	EC50		402
44	48	Bluegill	EC50		402

[illegible]	[illegible]	P. californicus	[illegible]			[illegible]
[illegible]	[illegible]	Daphnia Pulex	[illegible]			[illegible]
[illegible]	[illegible]	Simocephalus serrulatus	[illegible]			[illegible]
[illegible]	[illegible]	Simocephalus serrulatus	[illegible]	Immobilization	[illegible]	[illegible]
[illegible]	[illegible]	Daphnia Pulex	[illegible]	Immobilization	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	P. californica (Naiads)	[illegible]		[illegible]	[illegible]

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	10	Intraperitoneal	[illegible]
Rat	41	Oral	[illegible]

BENZENE

Benzene for use as a solvent and organic chemical building block is shipped in small glass bottles, one gal. cans, 5-55 gal. metal drums, tank cars, tank trucks, and barges. Some 8 billion lbs. were produced in 1971 (190). This is down from 9 billion lbs. in 1969 but should rise again.

Benzene is insoluble and lighter than water. Spills should result in formation of a clear slick on the surface of the water. The portion that dissolves is subject to limited biodegradation. Oxygen utilization is low during the first five days (8,11,13). After 10 days, as much as 1.2 lb oxygen may be consumed per lb of benzene (11). This agrees well with results indicating superior oxygen consumption after culture acclimation (8,13). Saturated solutions, approximately .1 percent benzene, can seriously retard sewage digestion.

Fish are sensitive to benzene in the 5-60 ppm range. A concentration of 10 ppm is lethal to trout (1). Wallen, et al., report much higher values, 386-395 ppm, for the 24-96 hr TLm response of mosquito fish in turbid water (1). Apparently, suspended solids can effectively absorb benzene or otherwise reduce its toxic effects. A concentration of 10 ppm had no effect on giant kelp during a 96 hr exposure period (1). In saltwater, the 48 hour TLm for brine shrimp is 21 ppm (425).

Median lethal doses from 5600 mg/kg (1) and 3000 mg/kg (63) body weight have been reported for adult and young rats, respectively. A maximum of .174 mg/kg body weight is suggested for human consumption (82). Benzene slicks at spill sites pose a major hazard to water fowl and marine mammals.

Other aquatic concentrations of interest include a recommended maximum prolonged contact level of 30,000 ppm (7) and an odor threshold of .04-53 ppm (30). Benzene produces tastes in water at the .5-4.5 ppm level (1). When chlorinated, toxicity and taste may be evidenced at even lower levels.

NAME Benzene

PRODUCTION QUANTITY 8 billion lbs 1971 (198)

SYNONYMS Benzol, Cyclohexatriene

COMMON SHIP OR CONTAINER SIZE Glass bottles, 1 gal cans, 5-55 gal metal drums, tank cars, trucks, barges

DOT Flammable Liquid, Red Label, 10 gal. outside container

USCG Grade C flammable liquid

M.P. 5.56 °C

B.P. 80.1 °C

Sp.G. 0.879

SOLUBILITY 820 mg/l at 22 °C

PERSISTENCE

Oxygen Demand

BOD .125 = <1% Theo. using phenol acclimated pure bacterial culture (5)
BOD .25 = 1.5% Theo. using aniline acclimated activated sludge at a treatment plant (5)
BOD .5 = 31% Theo. using phenol acclimated activated sludge (11)
BOD_5 = 0 lb/lb using sewage seed (11)
BOD_5 = 1.9% Theo. using sewage in quiescent environment (5)
BOD_{10} = 1.2 lb/lb using sewage seed (11)
COD = .83 lb/lb (64)
$BOD_{5,10,15,20}$ = 24, 27, 24, 29% Theo. in fresh water (425).
$BOD_{5,10,15,20}$ = 58, 67, 76, 80% Theo. - acclimated (425).

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	perm	cond	ref
5	6	Minnow	Lethal	Distilled, 16°C	1
5	6	Minnow	Lethal	Hard, 16°C	1
20	24 & 48	Sunfish	TLm	Philadelphia Tap Water	1
60	1	Sunfish	100% Killed		1
34	24	Sunfish	100% Killed		1
10		Trout	Lethal		1
395	24 &48	Mosquito Fish	TLm	Turbid, 20-22°C	1
386	96	Mosquito Fish	TLm	Turbid, 20-22°C	1
31-32	96	Bluegill & Goldfish	TLm	Const. Temp.	17

Saltwater Toxicity

ppm	hrs	Species	Para.	Cond.	Ref.
[illegible]	[illegible]	Brine Shrimp	TLm		[illegible]
[illegible]	[illegible]	Brine Shrimp	TLm		[illegible]

Mammalian Toxicity

Mammalian

Species	mg/kg B. W.	administration route	ref
Rat	[illegible]	Oral	[illegible]
Mammals	[illegible]	Oral	[illegible]
Young Rat	[illegible]	Oral	[illegible]

BENZOIC ACID

Benzoic acid is used in the synthesis of sodium benzoate resins and in nylon, pharmaceuticals and flavors. The 23 million lbs produced in 1969 (108) were shipped in a large variety of containers ranging from bottles to 150 pound bags. Production is expected to continue growth at 7 percent per year through 1976 (108).

Benzoic acid is only partially soluble in water. When spilled the crystals will sink and gradually dissolve. The acid does not dissociate completely and hence solution pH responds slowly. The calcium and sodium salts formed with neutralisation are soluble but less toxic than the acid. Dissolved benzoic acid is subject to biodegradation. As much as 1.4 lbs of oxygen per lb of acid can be utilised in the first 5 days (11). The P. fluorescens cultures are particularly effective in attacking benzoic acid, possibly causing localised oxygen deficiencies in spill situations. On the other hand, benzoic acid is employed commercially as a food preservative because of its ability to inhibit microorganisms. Hence, at concentrations high enough to cause oxygen slumps, bacterial action is likely to be retarded.

Benzoic acid is toxic to both fish and fish food organisms. Concentrations of 200 ppm and 550 ppm have been reported as lethal to goldfish and sunfish, respectively (1). The 96 hr TLm for mosquito fish in turbid water is 180 ppm (1). Daphnia are immobilized at 148 mg/l (1). Toxicity is reported to result from the undissociated acid molecule and hence may occur above pH 5.

Benzoic acid is considered only a slight ingestive hazard (38) and has been approved as a food additive. The oral LD50 for rats is reported as 1700 mg/Kg body weight (217), while that for dogs is 2000 mg/Kg (8). Subcutaneous and intravenous administration in tests for carcinoma proved negative (15).

NAME Benzoic Acid

PRODUCTION QUANTITY 93 million lbs 1969

SYNONYMS Benzene Carboxylic Acid, Phenylformic Acid, Dracylic Acid

COMMON SHIP OR CONTAINER SIZE 100-150 lb barrels, bags, fiber drums, cartons, bottles

M.P. 122.13 °C

B.P. 249.2 °C

Sp.G. 1.266

SOLUBILITY 2100 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

$BOD_{.083}$ = 66% Theo. with pure bacterial culture-(5)
$BOD_{.94}$ = 0.0% Theo. with phenol acclimated bacterial culture-(5)
BOD_5 = 1.4 lb/lb using sewage seed-(11)
BOD_8 = 75.2% Theo. with aniline acclimated activated sludge-(5)
BOD_{10} = 46% Theo. with quiescent sewage-(5)
COD = 1.98 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
200	7	Goldfish	Lethal		1
550	1	Sunfish	Killed		1
240	24	Mosquito Fish	TLm	18-21°C, Turbid	1
225	48	Mosquito Fish	TLm	18-21°C, Turbid	1
180	96	Mosquito Fish	TLm	18-21°C Turbid	1
146	Prolonged	Daphnia	Immobilized	Lake Erie, 25°C	1

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	2000	Oral	8
Rat	1700	Oral	217
Frog	100-200	Subcutaneous-Lethal	22

BENZONITRILE

Benzonitrile is supplied by a single producer in the U.S.

Benzonitrile is an oily liquid that is slightly soluble in water and only a little more dense than freshwater. As such, it should sink when spilled and dissolved to a limited extent. In saltwater it is liable to float. Since dissociation does not occur to any appreciable extent, no major output of HCN is anticipated. The dissolved portion is subject to biodegradation with anywhere from 40-60 percent of the theoretical oxygen demand realized in the first five days (10,65). Concentrated solutions, however, are capable of retarding biochemical action. Levels of 10 ppm have been reported to inhibit sewage organisms (65). Oxygen deficiencies are not expected in spill situations.

A solution of 5 ppm is reported to have had no effect on various fishes in Lake Huron(1). Median threshold limit values for fathead minnows, bluegill, and guppies fall in a range of 78-400 ppm (1). Comparative tests with fathead minnows reveal a higher toxicity in hard water than soft (1). In freshwater where benzonitrile will potentially sink, benthic life is endangered. Bluegills left for four weeks in water containing 35 ppm had no apparent change in flesh flavor (1).

An LD50 of 180 mg/kg is reported for subcutaneous administration to mice (8). Benzonitrile is thought to be less toxic than cyanides because of its lower volatility. Toxicological responses, however, will be similar to that for cyanides at lower doses.

NAME Benzonitrile

SYNONYMS Cyanobenzene, Phenyl Cyanide

M.P. -13.0 °C

B.P. 190.7 °C Explodes

Sp.G. 1.01

SOLUBILITY 10,000 mg/l at 100°C

PERSISTENCE

Oxygen Demand

BOD_5 = 60% Theo. using river water-(10)
BOD_5 = 40% Theo. using sewage seed-(65)
BOD_{12} = 80% Theo. using sewage seed-(65)
BOD_{12} = 90% Theo. Using river water-(65)
BOD_{18} = 60% Theo. using river water-(10)
BOD_{28} = 75% Theo. using activated sludge with chemical analysis for N_2-(10)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
5	24	Trout, Bluegill, & Sea Lamprey	No Effect	Lake Huron 12°C	1
16	24	Fathead Minnow	Tlm	Hard	4
78	48	Fathead Minnow	Tlm	Hard	4
78	96	Fathead Minnow	Tlm	Hard	4
240	24	Fathead Minnow	Tlm	Soft	4
180	48	Fathead Minnow	Tlm	Soft	4
135	96	Fathead Minnow	Tlm	Soft	4
78	24,48,96	Bluegill	Tlm	Soft	4
400	24,48,96	Guppy	Tlm	Soft	4

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	180	Subcutaneous	8

BENZOYL CHLORIDE

Benzoyl chloride is used in acetylation processes and as a dye intermediate. It is presently produced by six major U.S. firms and is shipped mainly in bottles, carboys, and tank cars.

Benzoyl chloride hydrolizes upon contact with moisture to form benzoic and hydrochloric acid. The benzoic acid is subject to biodegradation, but this process is likely to be retarded by the low pH resulting from the accompanying hydrochloric acid.

The aquatic concentrations of interest will be those for the benzoic and hydrochloric acid hydrolysis products. No aquatic data exists, but benzoyl chloride vapor is highly corrosive to skin. A TLV of 5 mg/m^3 has been set for this material.

NAME Benzoyl Chloride

SYNONYMS Benzene Carbonyl Chloride

COMMON SHIP OR CONTAINER SIZE Bottles, carboys, tank cars

DOT Corrosive Liquid, White Label, 1 qt. outside container

M.P. -1.0 °C

B.P. 197.2 °C

sp.G. 1.20

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Hydrolyses to Benzoic and Hydrochloric Acid

TOXICOLOGICAL

Fresh Water Toxicity

See benzoic and hydrochloric acids. HCl will control toxicity.

Salt Water Toxicity

See benzoic and hydrochloric acids. HCl will control toxicity.

BENZYL CHLORIDE

Benzyl chloride is used to manufacture benzyl compounds, perfumes, pharmaceuticals, dyes, resins, and synthetic tannins. The 74 million lbs produced in 1969 (199) were shipped in carboys, drums, tank cars, and tank trucks. Production is expected to continue to rise through 1975.(198)

Benzyl chloride is soluble to only 33 ppm in water. When spilled, it will seek the bottom and remain there. The water will slowly hydrolyze this submerged blanket forming benzyl alcohol and hydrochloric acid.

Benzyl chloride has been shown to have no effect on fish at 1 ppm and to cause only slight irritation at 10 ppm (1). However its hydrolysis to benzyl alcohol and hydrochloric acid suggests toxicity problems may result from spills.

Benzyl chloride is highly toxic by all routes of administration (38). It is intensely irritating upon contact with skin, eyes, or mucous membranes. Large doses can cause depression of the central nervous system (8). The low toxic dose to rats is 50 mg/kg body weight when administered subcutaneously (96).

NAME Benzyl Chloride

PRODUCTION QUANTITY 74 million lbs 1969

SYNONYMS α-Chlorotoluene

COMMON SHIP OR CONTAINER SIZE Carboys, drums, tank cars, tank trucks

DOT Corrosive Liquid; White Label, 1 qt outside container

M.P. -43 to -48 °C

B.P. 179 °C

Sp.G. 1.10

SOLUBILITY 33 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, etc.

Slowly hydrolyzes in water to benzyl alcohol and hydrogen chloride.

TOXICOLOGICAL

Fresh Water Toxicity

See benzyl alcohol and hydrogen chloride. HCl will control toxicity.

Salt Water Toxicity

See benzyl alcohol and hydrogen chloride. HCl will control toxicity.

ppm	hrs	species	harm	cond	ref
1		Fish	No Effect		1
10		Fish	Slight Irritant		1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	50	Low Toxic Dose	96

BERYLLIUM CHLORIDE

Beryllium chloride is used in the production of beryllium compounds. It is marketed by seven major U.S. firms.

Beryllium chloride is very soluble in water, forming a strong acid solution. The presence of carbonate and hydroxide in sufficient concentrations will lead to precipitation of the beryllium cation. Dilution of the spill area will also bring this about. The solubility constant for $Be(OH)_2$ at room temperature is 2×10^{-18}. Hence, a precipitate will develop following a spill.

The toxicity of beryllium salts is dependent in part on the accompanying solution pH. Low pH solutions are hazardous to fish in their own right while high pH solutions minimize beryllium solubility. Water hardness is also a controlling factor in determining the toxicity of beryllium chloride. Tarzwell and Henderson found the 96 hr TLm for fathead minnows increased from .15 ppm as beryllium in soft water to 15 ppm as beryllium in hard water (1). A 5 percent waste solution from a beryllium plant was reported safe for fish while a 10 percent solution was toxic (1).

Median lethal doses for rats vary from 4.4 mg/Kg when administered intraperitoneally (8) to 86 mg/Kg when administered orally (66). The value for mice is 93 mg/Kg (56). Excretion of beryllium is rapid. Absorption from the alimentary tract is .006 percent of that ingested. Rats were healthy after two years of being fed 10 mg Be/Kg/day (1). Dogs were healthy after 10 months of feed rations which included 10 mg $BeSO_4$/Kg/day(1). Drinking water for cattle should not exceed 6000 ppm Be(1).

Beryllium is hazardous to humans mostly as a suspended dust in the atmosphere. It is implicated in both skin and lung diseases and has had a TLV of .002 mg/cm^3 set for exposure in an 8 hr working day. Water soluble salts can also cause ulceration if contacted with breaks in the skin.

Beryllium also has phytotoxic characteristics when present in acid solutions. Concentrations of 15-120 mg/l Be delays germination and retards growth of cress and mustard seeds in solution culture (1). Above pH 11.2, beryllium can be beneficial to magnesium deficient plants.

NAME Beryllium Chloride

DOT Poison B, Poison Label, 200 lbs in outside container

M.P. 405.0

B.P. 520.0 °C

Sp.G. 1.90

SOLUBILITY Very soluble

PERSISTENCE

Chemical Hydrolysis, etc.

Hydroxide and carbonate salts are insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
0.15	96	Fathead Minnow	Tlm	Soft	(as Be) 1
15	96	Fathead Minnow	Tlm	Hard	(as Be) 1
5% Waste sol. from Be plant		Fish	Non-toxic		1
10% Waste sol. from Be plant		Fish	Toxic		1

Mammalian

species	mg/kg B. W.	administration route	ref
Rats	4.4	Intraperitoneal	8
Rat	86	Oral	66
Mouse	92	Oral	56

BERYLLIUM FLUORIDE

M.P. 800°C

Sp. G. = 1.986

SOLUBILITY - Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Hydroxide and carbonate salts of beryllium are insoluble.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that associated with the Fluoride ion.

Saltwater Toxicity - Toxicity will be that associated with the Beryllium ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rat	98	Oral	96
Mouse	100	Oral	96
Mouse	20	Subcutaneous	96
Mouse	1.8	Intravenous	96

BERYLLIUM NITRATE

Beryllium nitrate is used in the manufacture of incandescent gas lantern mantels. Some seven major U.S. firms presently market this material.

Beryllium nitrate is very soluble in water, forming a strong acid solution. The presence of carbonate and hydroxide in sufficient concentrations will lead to precipitation of the beryllium cation. Dilution of the spill area will also bring this about. The solubility constant for $Be(OH)_2$ at room temperature is $2x10^{-18}$. Hence, a precipitate will develop following a spill.

The toxicity of beryllium salts is dependent in part on the accompanying solution pH. Low pH solutions are hazardous to fish in their own right while high pH solutions minimize beryllium solubility. Water hardness is also a controlling factor in determining the toxicity of beryllium nitrate. Tarzwell and Henderson found the 96 hr TLm for fathead minnows increased from .15 ppm as beryllium in softwater to 20 ppm as beryllium in hard water (1). A five percent waste solution from a beryllium plant was reported safe for fish while a 10 percent solution was toxic (1).

The median lethal dose for rats is reported as 501 mg/Kg when administered intraperitoneally (8). The value for guinea pigs tested in the same manner is 50 mg/Kg (67). Excretion of beryllium is rapid. Absorption from the alimentary tract is .006 percent of that ingested. Rats were healthy after two years of being fed 18 mg Be/Kg/day (1). Dogs were healthy after 18 months of feed rations which included 16 mg $BeSO_4$/Kg/day(1). Drinking water for cattle should not exceed 6000 ppm Be (1). Nitrate levels for similar uses should not exceed 200 ppm (41).

Beryllium is hazardous to humans mostly as a suspended dust in the atmosphere. It is implicated in both skin and lung diseases and has had a TLV of .002 mg/cm^3 set for exposure in an 8 hr working day. Water soluble salts can also cause ulceration if contacted with breaks in the skin.

Beryllium also has phytotoxic characteristics when present in acid solutions. Concentrations of 15-120 mg/l Be delays germination and retards growth of cress and mustard seeds in solution culture (1). Above pH 11.2, beryllium can be beneficial to magnesium deficient plants (1).

NAME Beryllium Nitrate

M.P. 60.0 °C

B.P. 142.0 °C

Sp.G. 1.56

SOLUBILITY Very Soluble

PERSISTENCE

Chemical Hydrolysis, etc.

Hydroxide and carbonate salts are insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
.15	96	Fathead Minnow	TLm	Soft	(as Be) 1
20	96	Fathead Minnow	TLm	Hard	(as Be) 1
5% Waste Solution from Be plant		Fish	Safe		1
10% Waste Sol. from Be Plant		Fish	Toxic		1

Mammalian

species	mg/kg B. W.	administration route	ref
Guinea Pig	30	Intraperitoneal	8
Rat	50	Intraperitoneal	67

BRUCINE

Brucine is a derivative of strychnine, employed for denaturing alcohol and oils and as an analytical reagent for the separation of racemic mixtures. Brucine has also been patented for use as an additive in lubricants. Medicinally, brucine was used in a manner similar to strychnine to stimulate CNS activity depressed by poisons, to stimulate the circulatory system, and with cathartic drugs.

Brucine is soluble to 1200 ppm in water, forming a basic solution of pH 9.5.[8] Neutralization with acid leads to the formation of salts with the associated anions. Little is known of the persistency of solutions or of biological interactions. Similarly, no data is available with respect to aquatic toxicity.

Brucine is a highly toxic alkaloid to humans and other mammals. It resembles strychnine in its toxic action. The intravenous LD_{50} for dogs has been reported as 8 mg/kg body weight.[8] Solutions are very bitter, and can be detected by taste at 4.5 ppm.[8] Brucine is also considered an inhalation hazard.[12]

BRUCINE

SYNONYMS - Dimethoxystrychnine

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

M.P. 178°C

SOLUBILITY - 1200

PERSISTENCE

Chemical Hydrolysis, etc. - Solution is basic. Neutralization can lead to formation of related salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be similar to that of strychnine.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Dog	8	Intravenous	8
Rat	77	Intraperitoneal	96

BUTYL ACETATE

Butyl acetate for protective coatings, photo film, lacquer, and organic synthesis is shipped in containers ranging from glass bottles to tank cars. Production in 1969 reached 58,803,000 lbs (199).

Butyl acetate is soluble to 8,300 ppm. As such, it is likely to be evidenced as a clear slick on the surface of receiving waters when involved in a spill. The portion that dissolves is subject to some biochemical oxidation. An average BOD_5 value is 23.5 percent of the theoretical oxygen demand (36) or .15-.5 lb/lb butyl acetate with sewage seed (11). Residence for an additional 15 days increases oxygen utilisation to 57.4 percent of the theoretical value (36). This is not a sufficient rate to produce oxygen deficiencies in a spill situation.

Little is reported on the aquatic toxicity of butyl acetate. Fish food organisms have threshold limits in the range 44-320 ppm (1). E. Coli is unaffected at concentrations as high as 1,000 ppm (1). In saltwater, the 48 hour TLm for brine shrimp is 32 ppm (425).

Oral administration to rats and mice has revealed LD_{50} values of 4,130 and 7,060 mg/kg, respectively (1). Butyl acetate is considered a moderate toxicant for human ingestion. The irritant and narcotic properties of the vapor are of more concern. A TLV of 710 mg/m^3 has been set. Slicks resulting from spillage are a hazard to water fowl and marine mammals.

NAME Butyl Acetate

PRODUCTION QUANTITY 58,803,000 1969 (198)

SYNONYMS Butyl Ethanoate

COMMON SHIP OR CONTAINER SIZE Bottles, cans, steel drums, compartment tanks, drum cars, tank cars

DOT Flammable Liquid, Red Label, 10 gal outside containers

USCG Grade D combustible liquid

M.P. -76.8 °C

B.P. 117.5 °C

Sp.G. 0.883

SOLUBILITY 8300 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = .15-.5 lb/lb using sewage seed - (11)
BOD_5 = 23.5% Theo. using sewage seed-(36)
BOD_{20} = 57.4% Theo. using sewage seed-(36)
$BOD_{5;10;15;20}$ = 56, 68, 70, 83% Theo. in freshwater-(425)
$BOD_{5;10;15;20}$ = 40, 52, 56, 61% Theo. in saltwater-(425)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
44	48	Daphnia	TLm	23°C	1
320	96	Scenedesmus	TLm	24°C	1
>1000		E. Coli	No Effect	27°C	1

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
150	24	Brine Shrimp	TLm		425
32	48	Brine Shrimp	TLm		425

Mammalian Toxicity

species	mg/kg B. W.	administration route	ref
Rat	4130	Oral	1
Mice	7060	Oral	1

BUTYLAMINE

Butylamine is shipped in one gallon cans, five and 55 gallon drums, and tank cars for use in the production of tanning agents, pharmaceuticals, dyes, rubber, and insecticides. Approximately 26.6 million lbs were produced in 1969 (198).

Butylamine forms an alkaline solution with water in which it is miscible. The dissolved amine is then subject to biochemical oxidation. The reported BOD_5 is 26.5 percent of the theoretical oxygen demand with an additional 15 days increasing that to 48.8 percent (36). This is too slow a rate to produce oxygen slumps in a spill situation.

The toxicity of butylamine to fish falls within a critical range of 20-70 ppm (54). Limited data suggest the normal amine is slightly less toxic than the secondary and isobutylamines.

Butylamine is an irritant which can be toxic when administered by any route. The oral LD_{50} for rats is reported as 500 mg/kg (8). Dermal application to guinea pigs resulted in an LD_{50} of .464 mg/kg body weight (29). The vapors from butylamine can also be quite hazardous. A TLV of 15 mg/m^3 has been set.

NAME Butylamine

PRODUCTION QUANTITY 26.2 million lbs 1969 (198)

SYNONYMS 1-Aminobutane, N-Butylamine

COMMON SHIP OR CONTAINER SIZE 1 gal cans, 5 & 55 gal drums, tank cars

M.P. -50.0 °C

B. P. 78.0 °C

Sp.G. 0.80

SOLUBILITY Miscible

PERSISTENCE

Oxygen Demand

BOD_5 = 26.5% Theo. using sewage seed-(36)
BOD_{20} = 48.8% Theo. using sewage seed-(36)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
30-70	24	Creek Chub	Critical Range	River Water	(normal) 54
20-60	24	Creek Chub	Critical Range	River Water	(iso) 54
20-60	24	Creek Chub	Critical Range	River Water	(secondary) 54

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	500	Oral	8
Guinea Pig	464	Dermal	29

BUTYRIC ACID

Butyric acid appears in flavors, varnishes, and decalcification agents for treating hides. The 981,000 lbs produced in 1962 (109) were shipped in bottles, cans, drums, and tank trucks.

Butyric acid is listed as soluble to 56,000 ppm and as having a density close to that of water so that it will quickly mix in when spilled [Merck reports miscibility (8)]. Like most acids, it will be neutralized in natural waters as dilution occurs. The calcium, sodium and magnesium salts which would result are all quite soluble and will remain in solution. The butyrate radical, however, is subject to biochemical attack. A BOD_5 of .34-.9 lb/lb has been reported for tests using sewage seed (4). Acclimation of the seed advanced the oxygen uptake to 1.16 lb/lb (4). These rates appear rapid enough to produce localized oxygen deficiencies in a spill situation.

Butyric acid is toxic to fish and fish food organisms. The threshold of harmful effects to trout is reported as 100 ppm (1). A concentration of 400 ppm was lethal to trout[1] and 200 ppm constitutes the 24 hr TLm for bluegill (55).

Median threshold limits for Daphnia in 48 hrs and Scenedesmus in 96 hrs are 60 and 200 ppm respectively (1). Growth of chlorella pyrenoidosa is retarded by 340 ppm (4).

Merck reports an oral LD_{50} for rats of 8,790 mg/Kg body weight (8). This is considerably higher than the 2,940 mg/Kg reported elsewhere (74) and possibly suggests the existence of synergists or antagonists. Oettingen reports a mean lethal dose of 3600-3700 mg/Kg (1). The toxic hazard to man is considered low. Butyric acid has recorded a positive response to carcinogenic potential tests when fed at 25 percent in a synthetic diet for 3-35 wks (15).

NAME Butyric Acid

PRODUCTION QUANTITY 981,000 lb 1969 (199)

SYNONYMS Ethyl Acetic Acid, Butanoic Acid

COMMON SHIP OR CONTAINER SIZE Bottles, drums, cans, tank trucks

USCG Grade E combustible liquid

M.P. -7.9 °C

B.P. 163.0 °C

Sp.G. 1.000

SOLUBILITY 56,000 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = 30% Theo. with phenol acclimated activated sludge-(13)
BOD_5 = .34-9 lb/lb using sewage seed-(4)
BOD_5 = 1.15 lb/lb-(14)
BOD_5 = 1.16 lb/lb using acclimated seed-(4)
BOD_{20} = 1.45 lb/lb-(14)
COD = 1.65 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
120		Trout	Threshold of Harmful Effects		1
400		Trout	Lethal		1
60	48	Daphnia	TLm	23°C	1
200	96	Scenedesmus	TLm	24°C	1
61	48	Daphnia Magna	TLm	Const. Temp	59
200	24	Bluegill	TLm	Const. Temp.	59

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	8790	Oral	8
Rat	2940	Oral	74

CADMIUM

Cadmium occurs in small amounts in naturally occurring zinc ores, reflecting its close chemical relationship to zinc. According to Kopp and Kroner, cadmium is found only in minute traces in natural water. They reported that cadmium was found in less than three percent of all samples and that the mean of the samples with a positive occurrence was slightly less than 10 ug/l (253). Cadmium salts are used in the electroplating, ceramic, chemical and pigmentation industries. The chloride, nitrate, and sulfate are most commonly employed.

Cadmium is not very soluble in natural water as it has a marked tendency to form complexes such as the carbonates and hydroxides. The binding between the metal and halogen is also very strong. The low solubility of the carbonate, hydroxide, and sulfide complexes and the affinity of cadmium for hydrolysing and oxidizing sediments may cause a rapid precipitation of the metal after spillage. As with the other heavy metals, cadmium does not degrade in the aquatic environment. Very little is known of the distribution and fate of cadmium in the aquatic ecosystem. Dissolved cadmium may interfere with natural biological systems in water. As little as 142 ppm of the sulfate inhibits sewage organisms 50 percent.

McKee and Wolf indicate that the lethal concentration of cadmium for fish varies from 0.01 to 10 mg/l (1). Ball reported a continuous-flow 7 day TL50 value for rainbow trout of between 0.01-0.008 mg/l at hardness 200 mg/l. Pickering and Gast reported an 8 day TL50 value of 0.45 mg/l at hardness 200 mg/l (267). In the chronic study 0.037 mg/l was safe and 0.057 had an adverse effect on hatchability. Beisinger and Christensen reported a 48-hr LC50 value for Daphnia of 0.065 mg/l at hardness 48 mg/l. The three week LC50 was 0.005 mg/l with 0.0007 mg/l giving a 50 percent reproductive impairment, and 0.00017 mg/l having no effect (268).

Mount and Stephan report substantial accumulation of cadmium in the kidney, liver, gill, and gut of cadmium exposed bluegill (269). There appears to be no significant accumulation in the bone or muscle. The accumulation in the liver and gill are correlated with cadmium exposure. Liver accumulated cadmium up to approximately 50 ug/g (dry weight). There was substantial accumulation in the kidney but the amount was not closely related to cadmium exposure. Landner and Jernelov in a preliminary study were not able to demonstrate cadmium enrichment in guppies fed Tubifex containing cadmium (270).

Schroeder and Balassa found relatively large quantities of cadmium in shellfish, particularly oysters and lobsters (271). Yamagata and Shigematsu give values of cadmium in normal Japanese foodstuffs. The concentration of cadmium was high in liver and processed sea foods (272). Uthe and Bligh reported cadmium concentrations of less than 0.05 ppm (dressed fish) in several species of Canadian fish, while rainbow smelt from Lake Erie had a concentration of 0.06 ppm (248). Lucas et al. reported on several species of fish from the

Great Lakes. In whole fish the concentration of cadmium averaged 0.094 ppm and varied from 0.062-0.14 ppm (273). The cadmium concentration in the liver of 10 species of fish averaged 0.4 ppm and varied from 0.06 to 1.4 ppm.

The occurrence of the Itai-itai disease in Japan has focused attention on cadmium in the environment. Christensen and Olson stated that cadmium has probably more lethal possibilities than any other heavy metal (274). Cadmium is a cumulative poison and has a very long biological half-life in many animals. The body of a normal 70 kg man has been estimated to contain a total of 0.03 g of cadmium with 0.01 g concentrated in liver; this gives an overall concentration of 0.43 ppm. Schroeder et al. gives an estimate of a daily intake of 215 ug Cd with about 1-2 percent being accumulated. They estimated an intake of 15 ug Cd from water (275).

The oral LD50 for the white rat is 88 mg/Kg for cadmium chloride (8) and 72 mg/Kg for cadmium oxide (276). The subcutaneous LD50 for the dog is 27 mg/Kg using cadmium sulfate (8). It is known that cadmium is severely toxic to man both in terms of acute and long-term low level effects. The acute response syndrome is characterized by severe nausea, salivation, vomiting, diarrhea, abdominal pains, and myalgia. In addition liver and kidney damage may result. Doses of 100 mg Cd have been fatal to humans (208). Drinking water should not exceed .01 mg/l (1).

Experimental evidence suggests that cadmium causes many kinds of toxic effects including teratogenic and embryological effects, testicular atrophy, renal dysfunction, cirrhosis and necrosis of the liver, hypertension, arteriosclerosis, growth retardation, cancer, chronic disease of old age, etc. (15).

Cadmium has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

CADMIUM ACETATE

M.P. 256°C (anhydrous)

Sp. G. - 2.34

SOLUBILITY - Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Acetate is biodegradable. Cadmium will associate with particulate matter or precipitate as carbonate or hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity results from that of the cadmium cation.

CADMIUM BROMIDE

COMMON SHIP OR CONTAINER SIZE - Bottles, cans, cases

M.P. 568°C (anhydrous)

B.P. 861°C

Sp. G. - 5.192

SOLUBILITY - 1,210,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Cadmium will associate with particulate matter or precipitate as the hydroxide or carbonate salt.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity results from the cadmium cation.

NAME Cadmium Chloride

M.P. 568 °C

B.P. 960 °C

Sp.G. 3.327

SOLUBILITY 1,400,000 mg/l at 20 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Carbonates and hydroxides rapidly precipitate cadmium to low levels.

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	Species	Effect	Cond	Ref
0.0165	9.5-18	Goldfish	Killed	Distilled	1
0.10	>50	Young Eels	Max. Con. Tolerated		1
1.01	18.4	Young Eels	Avg. Survival Time	21 °C	1
45	24	Freshwater Fish	Lethal Con.		1
<0.0026		Daphnia	Immobilized	Lake Erie, 25 °C	1
0.1		Daphnia	Threshold Con.	River Havel	1
0.1		Scenedesmus	Threshold Con.	River Havel	1
0.15		E. Coli	Threshold Con.	River Havel	1
45	24	Orizias	Lethal Con.		1
$6x10^{-6}$M		Limnaea Palustris Eggs	Killed		75
.157M	1	European Carp	Survival Time		58
.000000017M	7	European Carp	Survival Time		58
0.9	96	Fathead Minnow	TLm	Soft	1
5.0	96	Fathead Minnow	TLm	Hard	1
1.05	96	Fathead Minnow	TLm	Soft	76
72.6	96	Fathead Minnow	TLm	Hard	76
1.94	96	Bluegill	TLm	Soft	76
1.27	96	Guppy	TLm	Soft	76
2.84	96	Sunfish	TLm	Soft	76
66	96	Sunfish	TLm	Hard	76

Mammalian

Species	mg/kg B.W.	administration route	ref
Rat	88	Oral	8
Rabbit	0.15-0.3	Oral	1
Dog	100-600	Oral as Cd	1

CALCIUM CARBIDE

Calcium carbide is a reducing agent employed in metal cutting, lampblack and cyanamide production, and acetylene generation. The 1.1 billion lbs. produced in 1971 (199) were shipped in sealed metal containers varying from 25 to over 1000 lbs. in capacity.

Calcium carbide decomposes violently upon contact with water to form calcium hydroxide and acetylene. Both of these may be toxic to aquatic life and may pose health hazards related to human consumption and water contact activities.

NAME Calcium Carbide

PRODUCTION QUANTITY 1.3 billion lbs. - 1971

SYNONYMS Acetylenogen, Carbide

COMMON SHIP OR CONTAINER SIZE 2 lbs-1000 lbs metal packages

USCG Hazardous

M.P. 2300 °C

Sp.G. 2.2

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, Etc.

Decomposes upon contact with water to calcium hydroxide and acetylene.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to calcium hydroxide.

Salt Water Toxicity

Refer to calcium hydroxide.

CALCIUM HYDROXIDE

Calcium hydroxide (calcium hydrate, slaked lime) is one of the most widely used substances in commerce and industry. Over 3 billion lbs. were produced in 1964 and shipped mostly by rail and truck in bulk or in wooden barrels or paper sacks as crystals or soft powder. Its major uses are in mortar and plaster, paints, medicines, agriculture, sugar juices, clarification and food treatment.

In case of a spill, the bulk of the calcium hydroxide will sink in water, and a small amount (solubility: 1850 ppm) will dissolve. The dissolved calcium will be minimized through precipitation as calcium carbonate due to the action of natural CO_2. It is probable that the slight amount of calcium hydroxide capable of being dissolved in solution would have minimal effect on microbial growth. The compound does have considerable buffering capacity which could be considered as a factor in causing eutrophication.

Calcium hydroxide is moderately toxic to common species. Goldfish, bass, and sunfish exhibited toxic effects after three hours exposure to 100 ppm, while 190 ppm was toxic to trout after 0.2 hour (1). For the mosquito fish, a 24 hour TLm value of 240 ppm has been established (1). No data on the effect of this chemical on salt water species were found, but it is probable that formation of relatively inert precipitates would limit its threat to marine life. Toxicity in general will be affected by solution pH, alkalinity and buffer capacity.

NAME Calcium Hydroxide

PRODUCTION QUANTITY 5 billion lbs - 1984

SYNONYMS Calcium Hydrate, Slaked Lime

COMMON SHIP OR CONTAINER SIZE Bags, barrels, bulk by rail or truck

M.P. 580 °C loses H_2O

B.P. decomposes

Sp.G. 2.344

SOLUBILITY 1,850 mg/l @ 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Natural carbonate will precipitate calcium.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
92	.7	Trout	Toxic	-	1
100	-	Goldfish	Toxic	pH 11.1	1
100	3	Goldfish	Toxic	-	1
100	3	Bass	Toxic	-	1
100	3	Sunfish	Toxic	-	1
100	-	Carp	Toxic	-	1
198	.2	Trout	Toxic	-	1
200	.5	Bass and Goldfish	Toxic	-	1
500	.3	Goldfish	Toxic	-	1
700	.7	Trout	Toxic	-	1
240	24	Mosquito-Fish	TLm	21-23 °C Turbid	1
220	48	Mosquito-Fish	TLm	21-23 °C Turbid	1
160	96	Mosquito-Fish	TLm	21-23 °C Turbid	1
300	24	Vector Snails	Lethal	28 °C	80

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	7340	Oral	8

CALCIUM HYPOCHLORITE

Calcium hypochlorite is employed as an algicide, bactericide, fungicide, deodorant, and bleaching agent. The 84 million lbs. produced in 1969 (199) were for the most part shipped in air tight cans, barrels, and steel drums.

Calcium hypochlorite undergoes a series of reactions when added to water. The hypochlorite attaches to free protons to form undissociated hypochlorous acid. This frees hydroxide ions which can join with the calcium and precipitate out at high concentrations. Natural carbonates will also reduce the calcium levels. The elevated pH, however, prevents formation of excessive hypochlorous acid. Hence an equilibrium is established. For instance, at pH6, 96 percent is present as hypochlorous acid, HOCl, while at pH9 this is reduced to three percent. The dissolved hypochlorous acid also undergoes combination reactions leading to an evolution of oxygen and chlorine with byproduct water formation. The hypochlorite and chlorine are both oxidizing agents which rapidly disappear in natural waters containing organics. The persistence of these agents will be inversely proportional to the chlorine demand. Hypochlorite may interfere with natural bacterial action through its bactericidal properties.

Calcium hypochlorite can be quite toxic to aquatic life. A concentration of .5 ppm is sufficient to kill trout (1). Algae is adversely affected at 2 ppm, hence the use of hypochlorite as an algacide (11). Because of the complex chemistry involved, solution pH, alkalinity, buffer capacity, and organic content will all play an important role in determining resulting toxicity.

Calcium hypochlorite is considered highly hazardous because of its ability to release toxic chlorine gas. On the other hand, it is commonly used in water treatment, sewage treatment, and swimming pool operations.

NAME Calcium Hypochlorite

PRODUCTION QUANTITY 84 million lbs - 1969

SYNONYMS Bleaching Powder, Chlorinated Lime

COMMON SHIP OR CONTAINER SIZE Air tight cans, barrels, steel drums

DOT Oxidizing material, yellow label, 100 lb. outside container

USCG Oxidizing material, yellow label

M.P. 100 °C decomposes

Sp.G. 2.350

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, Etc.

Decomposes to calcium hydroxide and hypochlorous acid. Some Cl_2 is formed.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
.5	-	Trout	Killed	-	1
20	72	Algae	Toxic	-	31

CALCIUM OXIDE

Calcium oxide is used in bricks, plaster, mortar, stucco, and other construction materials; in manufacturing steel, aluminum, and magnesium; for nonferrous ore flotation; in the production of glass, paper, sodium carbonate, calcium salts, and other chemicals; for dehairing hides; as a clarification agent; and as a sorbent for carbon dioxide. Annual production is high.

Calcium oxide decomposes in water to form calcium hydroxide. It is a strong irritant.

NAME Calcium Oxide

SYNONYMS Lime, Burnt Lime, Calx, Quicklime

M.P. 2580 °C

B.P. 2850 °C

Sp.G. 3.25

SOLUBILITY 1,110,000 mg/l @ 10 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Decomposes to calcium hydroxide.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to calcium hydroxide

Salt Water Toxicity

Refer to calcium hydroxide

CAPTAN

Captan is a halogenated thio-imide employed as a fungicide and insecticide. It is often applied in orchard areas. Approximately 18 million lbs were produced in 1971 (327) for use in the dust and wettable powder form.

Captan is insoluble in water, but may disperse at a reasonable rate if applied in the wettable powder form. Once in an aqueous environment captan hydrolyses rapidly. It has an effective residual life in water of two weeks (1). In soil, it may persist much longer. Munnecke notes residues last greater than 65 days and a second study on simulated seeds showed no concentration drop in 21 days (22). Griffith and Mathews, on the other hand, claim a half life of 1-2 days in soil (22). Soil moisture content may be the critical parameter causing this variation.

When captan was tested in lake water, it was found to kill 50 percent of the large trout present after 72 hrs at .32 ppm and 61 percent of the small trout after nine hrs at .56 ppm (1). Safe limits appeared to be 0.18 ppm (1). The 24 hr TLm for zebrafish has been reported as 10 ppm, but zebrafish larvae have a one hr TLm of 1 ppm (339).

Captan has been described as practically nontoxic to mammals. The oral LD50 for rats has been found in the range 8400 mg/Kg body weight (329) to 15,000 mg/Kg (1). The same value for rabbits is 3160 mg/Kg (1). Rats fed 1000 mg/Kg for one year showed no harmful effects (1). A chronic feeding limit of 4000 ppm in water has been set for dogs (328) while tests for carcinogenesis have been negative, but captan has been found to inhibit DNA synthesis when added to human cultures at 0.010 mg/l. Kangaroo rat cultures with 1.25-5.0 mg/l showed chromosome aberrations. Teratogenesis has also been implied in chickens fed 10-20 ppm. Offspring exhibited cleft palate and eye and bone anomalies. These results were not duplicated in mice, rats, or hamsters (56).

NAME Captan

PRODUCTION QUANTITY 10 million lbs - 1971 (327)

SYNONYMS Orthocide, Cis-N-(trichloromethyl thio)-4-cyclohexene-1,2-dicarboximide

M.P. 172 °C

Sp.G. 1.740

SOLUBILITY Insoluble

PERSISTENCE

Chemical Hydrolysis, Etc.

Readily hydrolyzes in aquatic environment.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
0.32	72	Large Trout	50% Kill		1
0.56	9	Small Trout	61% Kill		1
0.18	72	Trout	No Kill		1
0.32	72	Small Trout	No Kill		1
30	24	Zebrafish	TLm		339
1	1	Zebrafish Larvae	TLm		339

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	15,000	Oral	1
Rat	9,000	Oral	1
Rat	8,400	Oral	329
Rabbit	3,160	Oral	1
Rabbit	10	Oral - Low Toxic Dose	96

CARBARYL

Sevin, or carbaryl, is a carbamate insecticide used on vegetables, fruits, forage crops, poultry, and pets. The 45 million lbs produced in 1971 (327) were applied in the dust, granule, pellet, wettable powder, liquid, and fertilizer mixture forms.

Sevin is soluble to 1,000 ppm. When aplied, it will sink and slowly dissolve unless incorporated in a wettable form which will accelerate dissolution. In river water, sevin persists less than two weeks (328). When applied at 2 lb/acre, residues of 35 ppm were found on plants. These, however, had been reduced to 0.37 ppm by the 16th day (22).

Sevin is toxic to most aquatic life. The 96 hr TLm values for fathead minnows, rainbow trout, coho, and stickleback are 6.7 ppm (1), 1.35 ppm, 997 ppm and 3.99 ppm respectively (342). Toxicity to other species generally falls in this range (22). Fish food organisms may be affected by concentrations as low as .0017-.0076 ppm (184,303,335). Daphnia pulex are immobilized by .0064 ppm (335). In salt water, shrimp display a 48 hr TLm of .013-.027 ppm (330). The 24 hr LC50 for mullet has been reported as 4.25 ppm (331). Marine plankton is killed by .1-10 ppm (95).

Sevin can be toxic when ingested. The oral LD50 for rabbits and rats has been reported as 710 mg/Kg body weight (1) and 600 mg/Kg (8) respectively. The value in mule deer is given as 200-400 mg/Kg (22). Drinking water should not contain more than 0.1 ppm (337). In tests with white rats, no cumulative effects were noted (329). Carbamates produce a degradation product ETU which can cause a cancerous reaction on mammal skin (6). It is also known to produce point mutations in barley when fed at 1,000 ppm for 12 hrs (17).

Birds are not particularly sensitive to Sevin. The LD50 for young mallard ducks has been recorded as >2179 mg/kg while that for pheasants is >2000 mg/kg. Similarly, LC50 values are >5000 ppm for mallard ducks, pheasants, bobwhite and coturnix. Teratogenic effects have been noted from doses of 50 ppm or greater in birds (22).

Sevin at 2 lb/acre appears to have no effect on plants, particularly millet. On the other hand, it can be toxic to algae when present above 0.1 ppm (22).

NAME CARBARYL

PRODUCTION QUANTITY 45 million lbs - 1971 (327)

SYNONYMS 1-Naphthyl Methylcarbamate; Carbaryl; Arylam

M.P. 142 °C

Sp.G. 1.232

SOLUBILITY 1,000 ppm at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
5.6	96	Bluegill	TLm	Soft	1
6.7	96	Fathead	TLm	Hard	1
11.0	96	Bluegill	TLm	Soft H_2O	1
20.0		Goldfish	TLm		1
3.4	24	Bluegill	LC50		330
2.5	48	Bluegill	LC50		330
2.0	96	Bluegill	LC50		330
1.75	24	Longnose Killifish	LC50		331
13.0	96	Fathead	LC50		331
6.7	24	Stickleback	LC50		331
.99	48	Coho	TLm		305
1.35	48	Rainbow	TLm		305
5.30	48	Bluegill	TLm		305
10.45	48	Stickleback	TLm		305
6.7	24	Stickleback	TLm		305
.8 lb/acre		Crawfish	No Effect	Rice Paddys	314
.4	.09	Wild Larvae	47% Lethal	Flowing	302
.0048	96	Pteronarcys Cal. (Naiads)	LC50	Temp 15.5°C	304
.0017	96	Pteronarcella Badia (Naiads)	LC50	Temp 15.5°C	304
.0056	96	Claassenia Sabulosa (Naiads)	LC50	Temp 15.5°C	304
14	48	Goldfish	Lethal	50% Wettable Powder	306
28	48	Goldfish	Lethal	Tech. Grade	306
.25 lb/acre		Invertebrate Fish Food	50-97% Lethal	River	307
.997	96	Coho	TLm		342
1.350	96	Rainbow	TLm		342
3.990	96	Threespine Stickleback	TLm		342
2	72	Crawfish	TLm		366

ppm	hrs	species	parm	cond	ref
.0048	96	Pteronarcys Sp (Nymphs)	LC50	Temp 60°F	303
.0076	48	Simocephalus Serrulatus	Immobile	Temp 60°F	335
.0064	48	D. Pulex	Immobile	Temp 60°F	335
750	96	Tubifex + Limnodrilus Spp	LD50		362
2	48	Rainbow	EC50		354
2.5	48	Bluegill	EC50		354
19	48	Channel Catfish	EC50		354
0.015	48	Pteronarcys Californicus	EC50		354

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
1.6	48	Killifish	50% Kill		1
.027	48	Brown Shrimp	TLm		330
.013	48	White Shrimp	TLm		339
4.25	24	White Mullet	LC50		331
.1-10		Marine Plank-	Killed or No Growth		95
3	48	Oyster	TL_{50}		446

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	600	Oral	8
Rabbit	710	Oral	1
Rat	505	Oral	329

CARBON DISULFIDE

Carbon disulfide is used in the manufacture of rayon, as a soil disinfectant and solvent, and in the production of carbon tetrachloride and cellophane. The 800,000 lbs. produced in 1969 (199) were shipped in small glass and metal containers, 5 gal. cans, metal drums, tank trucks, tank cars, and barges.

Carbon disulfide is only slightly soluble in water. When spilled, it will seek the bottom and dissolve very slowly. Prior to dissolution, exposure to sunlight will initiate degradation accompanied by darkening to a yellow tint. Chlorination of carbon disulfide results in the production of carbon tetrachloride and sulfur. An obscure reaction has been noted in water. Pure carbon disulfide, without the trace color and odors found in technical grades, quickly gains back these properties when contacted with water. Return to the pure state requires the action of oxidizing agents. Carbon disulfide is likely to persist in a submerged layer for extended periods of time.

Carbon disulfide is toxic to sunfish at 100 ppm during a one hour exposure (1). Trout placed in 5000 ppm for seven minutes died two days later (1). The 24 hr. TLm for mosquitofish is reported to be 135 ppm (48). The threshold for perch and bleak has been reported as 35 ppm (1). The undissolved layer of carbon disulfide threatens benthic life forms with suffocation.

NAME Carbon Disulfide

PRODUCTION QUANTITY 800,000 lbs - 1969

SYNONYMS Carbon Bisulfide, Dithiocarbonic Anhydride

COMMON SHIP OR CONTAINER SIZE Small glass or metal containers, 5 gal. cans, metal drums, tank cars, tank trucks, barges

DOT Flammable liquid, red label--not accepted in outside containers.

USCG Grade B Flammable liquid

M.P. -108.6 °C

B.P. 46.3 °C

Sp.G. 1.263

SOLUBILITY 2,200 mg/l @ 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
100	1	Sunfish	Killed	Tap	1
5000	.1	Trout	Killed	-	1
135	48	Mosquito-Fish	TLm	Turbid	48

Mammalian

species	mg/kg B.W.	administration route	ref
Rabbits	300	Subcutaneous	8
Mammals	100-199	Oral	15

CHLORDANE

Chlordane is one of the chlorinated aromatic insecticide group. It typically contains 60-75 percent of the active octachlorohexahydromethanoindene agent and is applied as a dust, granule, wettable powder, or emulsion concentrate, or in solution. It is not applied to edible products because of its persistence.

Chlordane itself is insoluble in water, but may soon disperse if spilled in one of the wettable forms. When mixed with river water, chlordane was found to drop 85 percent in concentration over a two week period. It then remained at the reduced level through eight weeks (328). In soil, 55 percent of the original application remained after one year and 15 percent for three years. When applied at 15 lb/acre in soil, detectable levels persisted for more than 12 years. In a second test, 50 ppm in soil suffered 50 percent loss in 8 years and 100 ppm on sandy loam suffered 60 percent loss over 14 years (56).

Chlordane is highly toxic to aquatic life. The 96 hr TLm values for coho salmon, rainbow trout, stickleback, and fathead minnows have been reported as .056 ppm, .044 ppm, .090 ppm (342) and .069 ppm (1) respectively. In soft water, the value for the fathead minnow dropped to .052 ppm (1). Chlordane is similarly toxic toward fish food organisms. Freshwater shrimp display an LT50 of 0.5 ppm (343) while

Daphnia pulex suffer sublethal effects at .029 ppm (335). Chlordane is lethal to zooplankton in the range .1-.5 ppm and phytoplankton at .001-.5 ppm (345). In saltwater, the 96 hour TL50 to Korean shrimp is reported to be 0.015 ppm (431).

Chlordane is highly toxic when ingested. The lethal dose to man is 100 mg/Kg body weight (329). Ingestion should be kept below 0.3 mg/Kg (346) and drinking water should not exceed .003 mg/l (337). Tests with animals have revealed oral LD50 values of 305 mg/Kg for rats and 200 mg/Kg for rabbits (340). Although daily doses of 50 mg/Kg for 15 days resulted in death, the chronic oral toxicity has been reported as .125 mg/Kg over a two year period (1). Other studies show fatal effects to dogs from 660 mg/Kg and to cattle from .129 mg/Kg (1). As little as 25 mg/Kg can disrupt reproduction in quail (1). Tests for carcinogenesis have been negative (56).

Chlordane is a bioaccumulative material. Eastern oysters exposed to 0.01 ppm concentrated chlordane 7300 times in 10 days (22).

Chlordane is also phytotoxic. A concentration of 1 ppm over a four hour period reduced productivity of natural phytoplankton communities 94 percent (22). Further, the presence of 1, 10, and 100 ppm in soil has been found to alter the micro and macro nutrient balance in food crops (22).

NAME Chlordane

PRODUCTION QUANTITY 25 million lbs - 1971 (327)

SYNONYMS Velsicol, Toxichlor, Chlordan, Octachloro-4,7,-Methanotetrahydroindane

B.P. 175 °C

Sp.G. 1.67

SOLUBILITY Insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
.74	24	Channel Catfish	Lethal	Tap	223
.056	96	Coho Salmon	TLm	In Acetone	342
.057	96	Chinook Salmon	TLm	In Acetone	342
.044	96	Rainbow Trout	TLm	In Acetone	342
.090	96	Three Spine Stickleback	TLm	In Acetone	342
0.5	4	Freshwater Shrimp	LT50		343
0.5 lb/Acre		Mosquito Fish	70% Mortality	Pond	344
.015	96	Pteronarcys Sp (Nymph)	TLm	60°F	303
0.02		Simocephalus Serrulatus	Sublethal Effects	60°F	335
0.029		Daphnia Pulex	Sublethal Effects	60°F	335
.001-.5	7	Phytoplankton	Lethal		345
.1-.5	7	Zooplankton	Lethal		345
.015	96	(Naiads) Pteronarcys Californica	LC50	15.5°C	184
5		Trout Larvae	Disabling	In Emulsion	1
30		Trout Larvae	Disabling	In Acetone	1
0.03		Goldfish, Trout	Approx. Toxic Threshold		1
0.2		All Black Bass, Adult Bluegill, Bream	100% Kill	Pond	1
0.041	48	4-7 In. Trout	33% Kill		1
0.025	48	4-7 In. Trout	20% Kill		1
0.01		1.7 In. Bluegill	Toxic Threshold		1

ppm	hrs	species	parm	cond	ref
1 lb/ Acre		Bluegill	87% Kill	10% in Fuel Oil	1
.052	96	Fatheads	TLm	25°C, Soft	1
.069	96	Fatheads	TLm	25°C, Hard	1
.082	96	Goldfish	TLm	25°C, Soft	1
0.1	24	Bluegill	No Effect	13°C, Lake	1
0.19	96	Guppies	TLm	25°C, Soft	1
0.5	96	Catfish	TLm	25°C, Tap	1
1.0	3	Trout	Lethal	13°C, Lake	1
1.0	14	Sea Lamprey	Lethal	13°C, Lake	1
5	1	Trout	Lethal	13°C, Lake	1
5	2	Bluegill	Lethal	13°C, Lake	1
.25	96	Goldfish	100% Kill		1
.05	96	Goldfish	TLm		1
.022	96	Bluegill TLm	TLm		1
1.0	5	Bluegill	100% Kill		1
5.0	2	Bluegill	100% Kill		1
5.0		Carp Embryo	50-100% Mortality		141
0.022	24	Rainbow	LC50		110
0.010	48	Rainbow	LC50		110
.0070	96	Rainbow	LC50		110
.058	24	Bluegill	LC50		110
.05	24	Rainbow	LC50		111

Saltwater Toxicity

0.015	96	Korean Shrimp	TL50	431

Mammalian Toxicity

species	mg/kg B.W.	administration route	ref
Rat	395	Oral	140
Rabbit	200	Oral	140
White Rat	570	Oral	127

CHLORINE

Chlorine is used widely in the organic chemicals, pulp and paper, insecticide, and inorganic chemicals industries. It is commonly found in water and wastewater treatment plants as a disinfecting agent. Production reached 18.7 billion lbs. in 1971 (199) and has nearly doubled every 10 years in the recent past. (198) Chlorine is typically shipped in steel pressure cylinders, tank cars, and tank barges.

Chlorine when present in a spill will form a heavy gas cloud that clings near the ground. In contact with water, some will dissolve. If leaking tanks are submerged, the introduction into solution will be more complete. The chlorine that contacts with water immediately hydrolyses to produce hypochlorous acid and chloride ion. The hypochlorous acid dissociates to some extent such that at pH 6, 96 percent is present in the nonionic HOCl form and at pH 9, 3 percent (1). Waters containing organic and oxidizable inorganic matter display a chlorine demand. Most natural waters have such a demand and hence hypochlorous acid is soon reduced to chloride. The bacterial action of hydrolysed chlorine will upset normal biological patterns in receiving waters.

Chlorine is highly toxic to all forms of aquatic life. Concentrations of .03-5 ppm have been lethal to numerous species of fish. (1) The 168 hr TLm for trout has been reported as .08 ppm. (1) Daphnia, cyclops, and other micro-organisms are killed at the 2 ppm level. (1) Concentrations of .25-1.0 are employed to control algae. (1) In salt water, as little as .01-.05 ppm reduces normal activity in oysters. (1) Marine fish show extreme irritation at 10 ppm, while barnacles, tunicates, and bryoza are killed. (1) In general, the threshold concentration for fish has been set at .02 ppm chlorine. (41) Chlorine toxicity is highly dependent on pH, temperature, dissolved oxygen, and the synergism-antagonism of other dissolved materials such as ammonia. (1)

Chlorine is highly toxic if inhaled or ingested. Ingestion of water containing 90 mg/l (3.2 mg/Kg/day) can have strong physiological effects on humans. (56) Long term administration of large doses to rats has led to irritation of the upper digestive tract. (56) Chlorine has a median odor threshold in water of 3 ppm. (7) Use of chlorine in swimming pools has been implicated with irritant reaction. In most cases, however, the effect is one of pH rather than chlorine. (1)

Chlorine can be damaging to higher plant species. Exposure of giant kelp to .5 ppm over a 120 hr. period resulted in 10-15 percent reduction of photosynthetic action in the first two days followed by 50-70 percent reduction in days 5-7. (1) Irrigation water concentrations should not exceed 500 ppm. (1)

NAME Chlorine

PRODUCTION QUANTITY 18.7 billion lbs. - 1971

COMMON SHIP OR CONTAINER SIZE Steel pressure cylinders, tank cars, barges

DOT Nonflammable gas, green label, 150 lbs. in an outside container

USCG Nonflammable compressed gas

M.P. -101.6 °C

B.P. -34.6 °C

Sp.G. .0032

SOLUBILITY 14,600 mg/l @ 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydrolyzes in water to form hypochlorous acid and chloride ion.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
0.03	-	Rainbow Trout	Killed	-	1
0.05	23 days	Young Salmon	Critical level	-	1
0.08	7 days	Rainbow Trout	Half Killed	-	1
0.11 to 0.13	days	Fish	Harmful	-	1
0.15 to 0.2	12 to 16 days	Carp	25% Killed	-	1
0.2 to 0.3	-	Fish	Harmful	-	1
0.25	5	Fingerlings	Killed	-	1
0.3	2	Trout	Killed	-	1
0.3 to 1.0	-	Fish	Killed	-	1
0.8	47 min.	Small Trout	Killed	-	1
0.8	6	Golden Shiners	Killed	-	1
1.0	1	Trout	Killed	-	1
1.0	4 days	Many Types	Killed	-	1
1.0	-	Goldfish	Killed	-	1
1.0	-	Trout and Goldfish	Killed	-	1
2.0	-	Goldfish	Killed	-	1
2.0 to 4.0	-	Fish	10% Killed	-	1

ppm	hrs	species	harm	cond	ref
5.0	24	Green Sunfish	20% Killed	A	1
0.1	2.5	Small Trout	Not Harmed	–	1
0.1	–	Fish	Not Harmed	–	1
0.25	48	Goldfish	No Effect	–	1
0.2	2	Minnows	No Effect	–	1
0.5	–	Trout and Goldfish	Survived	–	1
1.0	–	Minnows	Survived	–	1
1.0	–	Goldfish	Recommended Threshold	–	1
1.0	100	Eels	Not Affected	–	1
1.0	–	Carp	Not Harmful	–	1
1.0	48	Fish	Max. Conc. Survived	–	1
2.0	48	Green Sunfish	No Mortality	–	1
2.0	48	Tadpoles	No Mortality	–	1
5.0	–	Goldfish	Survived	–	1
1	1	Eels Spp.	Lethal	Hard	[illegible]
0.5-5.0	0.17	Oyster Larvae	Withstand	30 °C Lab	[illegible]
10.0	2	Cladophora Sp.	Died	–	[illegible]
0.5	72	Daphnia	Killed	Soft	[illegible]
0.25	12	Rana Pipiens Tadpoles	Toxic	Temp. 76 °F	[illegible]
2	12	Bullfrog Tadpoles	Lethal	Temp. 76 °F	[illegible]
0.1	96	Fathead Minnow	TL50		[illegible]

Salt Water Toxicity

ppm	hrs	species	harm	cond	ref
10	6	[illegible]/Barnacles	Killed	–	1
10	1	Tunicates	Killed	–	1
10	1	Bryozoa	Killed	–	1
1		Marine Fish	Slight Irritation	–	1
10	–	Marine Fish	Extreme Irritation	–	1
0.01-0.05	–	Oysters	Reduced Activity	–	1
1	[illegible]	Oysters	Pumping Stops	–	1
1	120	Giant Kelp	No Effect	–	1
4	120	Giant Kelp	10-15% Reduction in photosynthesis after 2 days and 50-75% after 5-7 days	–	1

Other Aquatic Organisms

ppm	hrs	species	parm	cond	ref
0.25-3.0	-	Algae	Controlled	-	1
5-10	-	Synura	Killed	-	1
1.5-50	-	Chironomus	Killed	-	1
1	-	Minute Crustacea, Diatoms, Rotifers	Killed	-	1
.5	72	Daphnia	Killed	Soft	1
1	-	Daphnia	Controlled	-	1
2	-	Daphnia and Cyclops	Killed	Nile River	1
2.5	-	Freshwater Mussels, Snails, Sponges	Killed	-	1

CHLOROBENZENE

Chlorobenzene is used to produce DDT, phenol, and aniline. The 457,647,000 lbs produced in 1971 (198) were shipped in small glass bottles, 55 gal drums, tank cars, and tank barges.

Chlorobenzene is a heavy colorless liquid soluble to less than 500 ppm. As such, it will sink to the bottom of a watercourse when spilled and disseminate only slightly. Monochlorobenzene has shown some susceptibility to biochemical action with .03 lb oxygen consumed per pound of dissolved compound. This is far too low to create an oxygen slump in a spill situation. At the low levels likely to be seen after a spill, even this degradation is likely to occur to only a limited extent since natural organic foods will be preferred by resident bacteria. Halogenated aromatics in general have displayed persistency in natural waters at low levels.

Limited aquatic toxicity data indicate a 96 hr TLm range of 20-45 ppm for fish (37). A concentration of 2 ppm is toxic to algae in 3-21 days (33). While no specific data exists, chlorobenzene is considered potentially bioaccumulated like some of the more complex chlorinated aromatics. The tendency to form an insoluble blanket near the bottom of a waterway threatens benthic life forms.

Chlorobenzene is considered toxic via all routes. It can be absorbed through the skin. An LD_{50} of 2910 mg/kg body weight has been reported for rats (78). In air, 1,200 ppm can be narcotic to rats, and 3,700 ppm fatal. As a respiratory irritant, a TLV of 75 ppm has been set.

NAME Chlorobenzene

PRODUCTION QUANTITY 457,647,000 lbs 1971 (199)

SYNONYMS Monochlorobenzene, Benzene Chloride, Phenyl Chloride

COMMON SHIP OR CONTAINER SIZE Small glass bottles, 55 gallon metal drums, tank cars, tank barges

DOT Flammable Liquid, Red Label

USCG Grade D, combustible liquid

M.P. -45.0 °C

B.P. 132.1 °C

Sp.G. 1.107

SOLUBILITY 488 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD$_{12d}$ = 1% Theo. using phenol acclimated pure bacterial cultures (5)
BOD$_5$ = .03 lb/lb using sewage seed (11)
BOD$_5$ = 17.1% theo. using aniline acclimated activated sludge at a treatment plant (5)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	test	cond	ref
29	96	Fathead Minnow	TLm	Const. Temp.	17
24	96	Bluegill	TLm	Const. Temp.	17
45	96	Goldfish	TLm	Const. Temp.	17
44	96	Guppy	TLm	Const. Temp.	17

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	2910	Oral	78

CHLOROFORM

Chloroform for solvent use, for the production of refrigerants and fluorocarbons, and for use in pharmaceuticals is commonly shipped in bottles, tins, drums, and tank cars.

Approximately 230,440,000 lbs of chloroform were produced in 1971 (199). Production is projected to reach 300 million lbs in 1975 (198).

Chloroform, a heavy colorless liquid, is soluble to 1,000 ppm in water. It will sink to the bottom of a waterway when spilled. Dissolution will be slow, since the dissolved species are not particularly mobile. That which dissolves is not subject to any extensive biodegradation. From 0-.008 lbs of oxygen per lb of chloroform can be utilized during a five day period (11). This is not due to the inhibition of bacteria, but reflects the highly chlorinated nature of the compound. Chloroform has been found to have no effect on sewage organisms. Once spilled, chloroform is liable to persist in a bottom clinging blanket for a considerable length of time.

Fish can be anesthetized by chloroform just as people are. Levels of 100-200 ppm cause avoidance reactions in Sticklebacks, while 500 ppm is sufficient to cause a cease in respiration (1). As little as 10 ppm can cause fish to struggle and sink (1). Though this effect is quickly remedied with transfer to fresh water, it is especially hazardous in saturated solutions since the sinking fish will settle into the pure blanket at the bottom and suffocate. For similar reasons, benthic life forms are endangered by spills of chloroform. With 72 hour exposure, no toxic effect is noted in fathead minnows at 30 ppm, but lethality is noted at 100 ppm (426).

Numerous values have been reported for median lethal doses to test animals. In general mammals display oral LD_{50} values in the 1,000-2,499 mg/kg body weight range (15). It is recommended that humans not ingest more than .3 mg/kg body weight (63). Chronic threshold levels of .4 mg/kg and 12.5 mg/kg body weight have been reported for guinea pigs and albino rats respectively (15). Chronic damage appears to be directed to the liver and kidneys.

Chloroform has also been implicated as a genetically active substance. Seven of 20 mice developed tumors when given 8×10^{-4} and 4×10^{-4} cc doses in olive oil every four days for 30 periods (15). Mutagenic properties have also been discovered when administered to onions (15). Effects include chromosomal aberrations in root tips (19).

NAME Chloroform

PRODUCTION QUANTITY 230,440,000 lb 1971 (199)

SYNONYMS Trichloromethane

COMMON SHIP OR CONTAINER SIZE bottles, tins, drums, tank cars

M.P. -63.5 °C

B.P. 61.0 °C

Sp.G. 1.492

SOLUBILITY 1000 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = 0-.008 lb/lb using sewage seed (11)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
100-200		Stickleback	Avoid		1
500		Stickleback	Anesthetized		1
500	.3	Stickleback	Respiration Ceased		1
10	.3	Fish	Could be Revived		1
7100	72	Fathead Minnow	100% Kill	50°F,Huron	426
100	72	Fathead Minnow	Partial Kill	50°F,Huron	426
10	72	Fathead Minnow	No Toxic Effect	50°F,Huron	426

Mammalian

species	mg/kg B. W.	administration route	ref
White Mouse	1750	Oral	15
White Rat	1875	Oral	15
Guinea Pig	1750	Oral	15
Young Rats	450	Oral	63

CHLOROSULFONIC ACID

Chlorosulfonic acid is used to produce sulfone compounds, saccharine, and synthetic organics. The 107,060,000 lbs produced in 1963 (199) were shipped in wooden boxes containing glass or earthenware, 55 gal metal drums, and tank cars.

Chlorosulfonic acid decomposes violently upon contact with water to form hydrochloric and sulfuric acids. The resulting solution is strongly acid and will require time to neutralize.

The aquatic toxicity of chlorosulfonic acid will in fact be that of its hydrolysis products. Aside from specific toxicological reactions to sulfuric and hydrochloric acid, fish will die when the solution pH drops below 5.

The pure acid itself is very corrosive to skin and membranes. An MAC of 5 ppm has been set for hydrochloric acid. This may well be too high for its sulfurated forebear. The hazard of contact with vapor is augmented by the violent hydrolysis reaction.

NAME Chlorosulfonic Acid

PRODUCTION QUANTITY 107,068,000 lb 1962 (139)

SYNONYMS Sulfuric Chlorohydrin

COMMON SHIP OR CONTAINER SIZE Wooden boxes around glass or earthenware, 55 gal drums, tank cars

DOT Corrosive Liquid, White Label, 1 quart outside container

USCG Corrosive liquid

M.P. -80.0 °C

B.P. 151.0 °C

Sp.G. 1.766

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes on contact with water to sulfuric and hydrochloric acid.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to data on hydrochloric and sulfuric acids. Toxicity results from combined acidity.

Salt Water Toxicity

Refer to data on hydrochloric and sulfuric acids. Toxicity results from combined acidity.

P15=

CHROMIUM

Hexavalent chromium salts are used in metal pickling and plating operations, anodizing aluminum, the leather industry, and the manufacture of paints and dyes, explosives, ceramics and paper. In addition they are added to cooling water for corrosion control. In nature chromium is present in minor amounts in igneous rock. Natural water contains only a trace amount of chromium. Usually chromium is found in sea water in concentrations less than 1 ug/l. Kopp and Kroner reported that chromium was found in 24.5 percent of their samples, with a mean of positive samples being 9.7 ug/l and a range of 1-112 ug/l (253). Typical hexavalent compounds include chromates, dichromates, and chromic acid. Common trivalent forms include chromic chloride, nitrate, and sulfate; and chromites. Chromic acid is shipped mostly by train and truck.

Mertz (277) and Udy (278) have summarized the chemistry of chromium in water. Generally speaking hexavalent chromium exists in true solutions, regardless of the hydrogen ion concentration or the presence of other ions. Depending on pH and concentration of chromium ionization, chromium salts forms chromates, hydrochromate, and dichromate ions. The solubility of trivalent chromium is dependent on water quality characteristics such as pH, hardness, and alkalinity. Trivalent chromium has a strong tendency to form coordinating compounds, complexes, and chelates. Common salts are soluble.

Hexavalent chromium is a strong oxidizing agent and tends to be reduced to the trivalent state. Moore et al. state that short of massive slug doses, chromate is unlikely to harm the operation of a sound sewage treatment plant. The chromate that is retained in a sewage treatment plant is reduced to trivalent chromium (279).

Dowden and Bennett reported a 100 hr TL50 value of 0.4 mg/l for potassium dichromate for Daphnia magna (59). Pickering and Henderson reported 96 hr TL50 values from 18 to 118 for four species of fish tested in soft water, hardness 20 mg/l (250). Trama ran bioassays of two salts of hexavalent chromium and found that potassium dichromate was more toxic to bluegills than potassium chromate. They explain this greater toxicity of dichromate in terms of the ionization equilibria. The ionization is dependent on the hydrogen ion concentration and concentration of chromium. They conclude that the hydrochromate ion is more toxic than the chromate ion (280).

Olson exposed chinook salmon for seven months to continuous-flow concentrations of potassium dichromate. The test was started with newly spawned eggs and there was no significant mortality at any concentration tested. At the end of the fry stage significantly fewer fish had survived in the high test concentration of 0.18 mg/l. Increased mortality became evident at 0.08 mg/l during the fingerling stage. After seven months growth retardation was probably significant in the fish exposed to 0.016 mg Cr/l (281). In chronic tests with the fathead minnow Pickering (personal communication) found in hard water (200 mg/l $CaCO_3$) that 4 mg Cr/l was an "unsafe" concentration for the fathead minnow, and 1 mg Cr/l had no adverse effect on survival, growth, or reproduction. Benoit (personal communication) found that for brook trout tested in soft water (40 mg/l $CaCO_3$) 0.4 mg Cr/l had no adverse effect and 0.8 mg Cr/l was "unsafe".

Mertz (277) concludes that there is a strong indication that chromium has an important function in animal nutrition and indicates that chromium probably functions in biological systems in the trivalent state. Chromium in the trivalent state can be consistently detected in biological materials. Animal tissue contains the element to varying degrees depending on species, age, and geographic area. Total chromium in a typical daily institutional diet has been given as 78 ug/l.

Lucas et al. found an average concentration of 1 ppm in whole fish (273). Knoll and Fromm exposed rainbow trout to 2.5 mg/l of hexavalent chromium and found that chromium was accumulated in the spleen, posterior gut, pyloric caecae, stomach, and kidneys, and only insignificant amounts were accumulated in muscle tissue (282). Elimination studies showed a rapid loss of chromium from blood, liver stomach, pyloric caecae, and posterior gut. Spleen and kidney retained chromium. Fromm and Stokes found that rainbow trout can accumulate chromium from water containing as little as 1 ug/l. At a concentration of 10 ug/l the uptake of chromium levels off after 10 days'exposure indicating excretion is equal to uptake (283). Kariya et al. studied the concentration of chromium in various tissues and organs of fish exposed to chromium, as a method for post-mortem identification of the pollutant. They found high concentrations of chromium in the skin, 110-314 ppm, and gill, 284-615 ppm. Other organs that concentrated chromium were kidney, spleen, hepatopancreas, and digestive organs. Muscle contained 3.3-9.8 ppm (284).

Hexavalent chromium at 1 mg/l for 7-9 days causes a 20-30 percent reduction in photosynthesis of the giant kelp, Macrocystis pyrifera. The concentration of chromium required to cause a 50 percent reduction of photosynthesis in four days was estimated at 5 mg/l (48). Harvey studied the effect of chromium on the growth of unicellular chlorophyceae and diatoms. Five species were unable to grow in concentrations above 0.32 ppm. Diatoms were least tolerant. In sublethal concentrations growth was stimulated (285).

The subcutaneous LD50 for chromium trioxide for the dog is 330 mg/kg (8). Dogs tolerated up to 11.2 ppm of hexavalent chromium in water for four years without any ill effects. Byerrum et al. did not find any toxic response in rats after one year at drinking water levels of up to 25 mg/l (1). Gross & Heller found that the maximum nontoxic level of hexavalent chromium in drinking water for rats was 500 mg/l. Growing chickens showed no detrimental symptoms when they were fed 100 ppm in the diet (1).

The chromate ion penetrates all membranes quite readily and is a strong oxidizing agent. These properties are the basis for its irritating effects and greater toxicity than that of the trivalent form. When inhaled, chromium is a known carcinogenic agent for man. It is not known whether cancer will result from ingestion of chromium in any of its valence forms. Drinking water standards set a limit of 0.05 mg/l for hexavalent chromium, but none for trivalent chromium. The limit for hexavalent chromium was based on the lowest amount analytically determinable at the time it was established (1).

Chromium can be toxic to plants at all levels according to Klintworth (1). Concentrations of 3.6-17.3 mg/l trivalent chromium were slightly toxic to plants. The chromate ion had slightly greater effects than the chromic ion.

AMMONIUM CHROMATE

Ammonium chromate is employed in making textiles, light sensitive paper, wool bleaching, and in chemical laboratories. It is presently marketed by two U. S. firms.

Ammonium chromate is readily soluble, forming an alkaline solution in water. Detectable ammonia vapors are released from the compound and its solution. The chromate ion is most likely to persist in the hexavalent state once spilled. Whereas biodegradation of the ammonium is feasible, it is likely to be inhibited completely by the presence of chromate. Presence of organics can lead to reduction of the chromate.

Wallen, et al., found a 96 hr Tlm for mosquito fish in highly turbid water of 240 ppm (1). This appears high for the salts involved and may be the result of specific absorption of chromate onto the suspended particles. In general, the threshold concentration for chromate to fresh and salt water fish is .05 ppm (41) and that for free ammonia is .5 ppm (41). Trout have been noted to accumulate hexavalent chromium when present at levels as low as .001 ppm. Brown algae can concentrate chromium 100-500 times (1). PH is very important in determining ammonium chromate toxicity.

Ammonium chromate is irritating to the touch and dangerous if retained in the body. Aquatic concentrations of interest include a taste threshold range of 1.4-25 ppm chromate (49), drinking water limits of .05 ppm chromate (1), a body contact exposure level of 1 ppm chromate (48), and a general farm use concentration of .05-5 ppm (42). Aquatic plants can tolerate up to .05 ppm chromate (1). Prolonged human contact should not be made with water containing more than .05 ppm chromate (1).

Chrome dusts have been implicated in lung cancer development (50).

NAME Ammonium Chromate

M.P. 180 °C Decomposes

Sp.G. 1.91

SOLUBILITY 405,000 mg/l at 30°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
240	96	Mosquito Fish	TLm	Highly Turbid Water	1
270	48	Mosquito Fish	TLm	Highly Turbid Water	40

AMMONIUM DICHROMATE

Ammonium dichromate for photoengraving, lithography, pyrotechnics, chemical laboratories, and use as a mordant is generally shipped in 350 lb wooden barrels or 100 lb fiber drums. It is presently marketed by seven major firms.

Ammonium dichromate is highly soluble, forming an acid solution when dissolved. A one percent solution has a pH of 3.95. Elevation of the pH will lead to production of chromate and release of ammonia gas. Presence of organic water will lead to chemical oxidation of the organics and subsequently reduction of the hexavalent chromium to its trivalent state.

Wallen, et.al., found a 96 hr TLm for mosquito fish in turbid water of 136 ppm (1). This appears high for the salts involved and may be the result of specific absorption of chromate onto the suspended particles. In general, the threshold concentration for chromate to fresh and salt water fish is .05 ppm (41) and that for free ammonia is .5 ppm (41). The acid nature of the solution may reduce the toxicity of the ammonium cation since pH is a critical parameter in the determination of ammonium dichromate toxicity. Trout have been noted to accumulate hexavalent chromium when exposed to levels as low as .001 ppm. Brown algae can also concentrate chromium 100-500 times (1).

Ammonium dichromate was found to be lethal to guinea pigs when administered subcutaneously at 10 mg/Kg body weight(8). It is an irritating substance for which recommended drinking water requirements are set at .05 ppm chromate (1). Body contact exposures should be kept below 1 ppm chromate (40) with prolonged contact maintained below .05 ppm chromate (1).

Other aquatic concentrations of interest include a taste threshold range of 1.4-25 ppm chromate (40); a recommended maximum concentration of .05 ppm chromate for livestock use and 5 ppm chromate for irrigation uses (42). Aquatic plants tolerate up to .05 ppm chromate (1).

This allergen has been connected with an increased incidence of lung cancer in people exposed to suspended dust.

NAME Ammonium Dichromate

SYNONYMS Ammonium Bichromate

COMMON SHIP OR CONTAINER SIZE 350 lb wooden barrels, 100 lb fiber drums

M.P. 170 °C Decomposes

Sp.G. 2.150

SOLUBILITY 357,000 mg/l at 20°C

PERSISTENCE

Chromium can be bioconcentrated 2000 times (429).

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm.	cond	ref
170	96	Mosquito Fish	TLm	Turbid	1
212	48	Mosquito Fish	TLm	Turbid	6

Mammalian

species	mg/kg B. W.	administration route	ref.
Guinea Pig	.30	Subcutaneous Lethal Dose	8

CALCIUM CHROMATE

Calcium chromate is a yellow crystalline compound shipped in bags and drums. It is employed as a pigment, a corrosion inhibitor, an oxidizing agent, and a depolarizer for batteries. It may also be utilized in the production of chromium.

Calcium chromate is soluble to 224,000 mg/l, forming a yellow solution. The salt dissociates upon entry into the water where both ions are relatively stable. Under reducing conditions, however, the chromate will be reduced to the trivalent form and precipitated as chromic hydroxide.

While no data is available on the aquatic toxicity of calcium chromate, solutions will display the same toxic characteristics as other hexavalent chrome compounds, e.g., sodium chromate. Data on chromium toxicity in general can be found in the profile on the metal itself.

Calcium chromate is reported to be characterized by a low lethal dose in rats of 40 mg/kg body weight when administered intramuscularly.[illegible] Drinking water limits and guidelines for general use should be extracted from those on hexavalent chrome in general as detailed in the profile on the metal itself.

CALCIUM CHROMATE

SYNONYMS - Steinbuhl Yellow, Gelbin, Yellow Ultramarine, Calcium Chrome Yellow, C. I. Pigment Yellow 33, C. I. 77223

COMMON SHIP OR CONTAINER SIZE - Bags, drums

M.P. - $2H_2O$ at 200°C

Sp. G. = 2.89

SOLUBILITY = 224,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Both ions are relatively stable under normal conditions. If a reducing environment prevails, the chromate will be reduced to the trivalent form and soon precipitated as chromic hydroxide.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the chromate ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rat	40 Low Lethal Dose	Intramuscular	96

CHROMIC ACETATE

SOLUBILITY - Slightly soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Trivalent chrome precipitates as chromic hydroxide. Acetate ions are biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for trivalent chromium.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Mouse	2.29 Low Lethal Dose	Intravenous	96

CHROMIC ACID

The 42 million lbs of chromic acid produced in 1969 (199) were shipped mostly by rail and truck in iron drums and glass containers. Chromic acid is used widely in industry: in chromplating, photography, electrical manufacture, etching, and medical equipment production.

Chromic acid, like hexavalent chromium salts, can be corrosive. Chromic acid will dissolve rapidly when spilled but may be reduced and neutralized by natural carbonates forming practically insoluble chromium carbonate. Dissolved in the trivalent or hexavalent state, chromium can interfere with natural biological processes. A concentration of 5 ppm is sufficient to retard the digestion of sewage sludge (1).

Limited fresh water data show chromic acid to be lethal to goldfish at a dose of 52 ppm in 96 hrs (1). The 96 hr TLm for fathead minnows was 33 ppm, for brook trout, 50 ppm, and for rainbow trout, 69 ppm (288). The 48 hr TLm for Daphnia was found to be 0.01 ppm (109. In general, hexavalent chrome should not exceed .01 ppm for propagation of fish (41). Aquatic life can concentrate chromium by factors of 100-500.

Chromic acid is highly toxic when ingested or inhaled. The oral LD_{50} for dogs is reported as 330 mg/Kg body weight (8). Drinking water should be limited to less than .05 ppm while that for livestock should be kept below 5 ppm (1).

chromium is also toxic to plants and should not exceed .05 ppm in irrigation water (1).

Inhalation of chromate dusts has been associated with lung cancer (15).

NAME Chromic Acid

PRODUCTION QUANTITY 42 million lbs - 1969 (199)

SYNONYMS Chromic Anhydride, Chromium Trioxide

COMMON SHIP OR CONTAINER SIZE Iron drums, glass bottles

DOT Oxidizing Material, Yellow Label, 100 lb in an outside container

USCG Oxidizing material, yellow label

M.P. 197 °C decomposes

B.P. 197 °C decomposes

Sp.G. 2.7

SOLUBILITY 1,649,000 mg/l at 0 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
52	96	Goldfish	Died		1
.01	48	Daphnia	TLm		109
33	96	Fathead Minnow	TLm		286
1	96	Fathead Minnow	Safe		286
50	96	Brook Trout	TLm		286
.06	96	Brook Trout	Safe		286
69	96	Rainbow Trout	TLm		286
.03	96	Rainbow Trout	Safe		286

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
100	48	Brown Shrimp	LC50	Aerated	411

Mammalian Toxicity

species	mg/kg B.W.	administration route	ref
Dog	330	Oral	8

CHROMIC SULFATE

M.P. - 100° C

B.P. - Loses water of hydration 10 at 100° C

Sp.G. - 1.867

SOLUBILITY - 670,000 mg/l, decomposes in hot water

TOXICOLOGICAL

FRESHWATER TOXICITY - Toxicity will be that for chromate ion

MAMMALIAN TOXICITY

Species	mg/kg B.W.	Administration Route	Ref.
Mouse	847	Intravenous - LD_{LO}	96

CHROMOUS CHLORIDE

SYNONYMS - Chromium Chloride

M.P. 824°C

Sp. G. = 2.751

SOLUBILITY - Soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Will oxidize upon standing to the oxychloride form. Trivalent chromium will precipitate as chromic hydroxide. Oxidation further will lead to higher concentrations of hexavalent chromium in solution.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of trivalent chromium.

CHROMYL CHLORIDE

SYNONYMS - Chromium Dioxychloride, Chromium Oxychloride;
Dioxodichlorochromium, Dichlorodioxochromium;

DOT - Corrosive Liquid, White Label, 1 gallon in an outside container.

M.P. -96.5°C

B.P. 117°C

Sp. G. = 1.91

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Hydrolysis vigorously on contact with water forming CrO_3 and HCl. Reducing conditions may lead to precipitation of trivalent chromic hydroxide.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for hydrolysis product CrO_3.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Mouse	5.45	Subcutaneous	96

LITHIUM DICHROMATE

SYNONYMS - Lithium Bichromate

M.P. 130°C

B.P. - Decomposes

SpG. - 2.34

SOLUBILITY - 1,510,000

PERSISTENCE

Chemical Hydrolysis, etc. - Chromate is relatively stable in the aquatic environment unless reducing conditions prevail, in which case, the trivalent form predominates and is precipitated as chromic hydroxide.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the bichromate ion.

LITHIUM CHROMATE

M.P. - H_2O at 150°C

SOLUBILITY - 1,410,000

PERSISTENCE

Chemical Hydrolysis, etc. - Chromate ion relatively stable in water but under reducing conditions may be reduced to a trivalent form which will subsequently be precipitated as chromic hydroxide.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of chromate ion.

POTASSIUM CHROMATE

Potassium chromate is employed in metal pickling and planting, aluminum anodizing, tanning, ceramics, and the production of explosives, paints and dyes. Sodium chromate is beginning to replace the potassium salt for many of these uses. The 6.2 million lbs produced in 1969 (190) were shipped in metal and fiber drums, multiwall bags, tank cars, and tank trucks.

Potassium chromate is a readily soluble oxidizing agent that forms a solution alkaline to phenothalin. The chromate ion is quite stable in the type of environment common to natural waters as is the potassium ion. Under anaerobic conditions the chromate could possibly be reduced. Potassium chromate can interfere with normal biochemical systems in water. A concentration of 10.6 ppm is sufficient to reduce oxygen utilization in sewage 50 percent.

Potassium chromate is toxic to most aquatic life. Fish are affected in the range 10-150 ppm (1). The 96 hr TLm for fathead minnows is reported as 45.6 ppm in soft water (76), while that for bluegill is 168.0 ppm (130). The threshold for various fish food organisms ranges from 0.016 to 40.6 ppm (1). Photosynthetic action in giant kelp is reduced 50 percent when it is exposed to 5 ppm chromium (1). In general, safe limits for chromium in water are 1 ppm for fish and

.05 ppm for other aquatic life (1). Solution pH, temperature, hardness, and dissolved oxygen content are all critical parameters in determining resulting toxicity. Salt water species appear to be as sensitive to chromate as freshwater species, although mummichogs have been shown to tolerate 200 ppm (1). Aquatic life can concentrate chromium. Algae has been found to concentrate it by a factor of 100-500 while trout can accumulate chromate from water when present at levels as low as 1 ppb (1).

Potassium chromate is highly toxic when ingested or inhaled. The intravenous LD50 for rabbits is reported to be 12 mg/Kg body weight (8). On the other hand, rats have been fed 1/mg/l in drinking water and rabbits 500 mg/l in drinking water for extended period with no ill effects (56). Similarly, 100 mg/Kg body weight had no effect on growth or mortality in chicks (1). Drinking water should not contain more than .05 ppm chromium (1), nor should water for livestock (43).

Potassium chromate is an irritant. Water for body contact should not contain more than 1 ppm (40) and concentrations in water for prolonged contact should not exceed .05 ppm chromium (1).

Chrome dusts are quite hazardous if inhaled. Carcinoma may result from breathing chromate salt dusts (8). A TLV of 0.1 mg/m^3 has been established.

Chromate can be toxic to plants. Irrigation water should not contain more than 5 ppm chromium (42). Plants such as barley can absorb chromium into their structure.

Potassium chromate can be tasted in water at the 1.5 ppm level (1).

NAME Potassium Chromate

PRODUCTION QUANTITY 6.2 million lbs 1959 (198)

SYNONYMS Tarapacaite

COMMON SHIP OR CONTAINER SIZE Metal and fiber drums, multiwall paper bags, tank cars, tank trucks

M. P. 975. °C

B. P. 1000. °C

Sp. G. 2.73

SOLUBILITY 629,000 mg/l at 20°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
45.6	96	Fathead Minnow	TLm	Soft	76
7.8	120	Nitzschia Linearis	TLm		118
16.8	96	Physa Heterostropha	TLm		118
182.8	96	Bluegill	TLm		118
400	96	Mosquito Fish	TLm	17-21°C	1
5		Fish	Toxic		1
5.2		Brown Trout	Toxic		1 ($K_2Cr_2O_7$)
7.1		Carp	Not Harmed		1 ($K_2Cr_2O_7$)
9		Fish	Toxic Limit		1 (CrO_4)
10			Only Slightly Hazardous		1 ($Na_2Cr_2O_7$)
10		Silver Salmon	Fresh Water Toxic		1
20		Rainbow Trout	Toxic	18°C	1 ($K_2Cr_2O_7$ & K_2CrO_4)
35.1		Goldfish	Not Harmed		1 ($K_2Cr_2O_7$)
45	480	Bluegills	Tolerated	Hard Water	1 ($K_2Cr_2O_7$)
50	11	Trout	Killed		1 ($K_2Cr_2O_7$)
50	720	Bluegills	Toxic Limit		1
52	60	Young Eels	Tolerated		1 ($K_2Cr_2O_7$)
52	.5	Goldfish	Toxic		1 (CrO_3)
52	96	Goldfish	Survived		1 (CrO_3)

PPM	HRS	SPECIES	DATA	COND	REF
60	120	Bluegills	Tolerated	Hard Water	1 ($K_2Cr_2O_7$)
70	168	Bluegills	Toxic Limit		
75	96	Bluegills	Died		1 ($K_2Cr_2O_7$)
82	240	Bluegills	Tolerated		1 ($K_2Cr_2O_7$)
103	24	Trout	Tlm		1 (K_2CrO_4)
100	8	Trout	Fatal		1 ($K_2Cr_2O_7$)
103	96	Bluegills	Tlm		1 ($K_2Cr_2O_7$)
104	8-84	Goldfish	Toxic		1 (CrO_3)
110	96	Sunfish	Tlm		1 ($K_2Cr_2O_7$)
113	96	Sunfish	Tlm		1 ($K_2Cr_2O_7$)
120	50	Young Eels	Tolerated		1 ($K_2Cr_2O_7$)
125	96	Sunfish	Tlm	Hard Water	1 ($K_2Cr_2O_7$)
145	24	Bluegills	Tlm		1 ($Na_2Cr_2O_7$)
148		Bluegills	Toxic Limit		1 ($Na_2Cr_2O_7$)
170	96	Sunfish	Tlm		1 (K_2CrO_4)
177	72	Goldfish	Toxic		1 ($K_2Cr_2O_7$)
180-360		Several Species	Toxic		1
196		Large Mouth Bass	Tlm		
213	48	Bluegills	Tlm		1 ($Na_2Cr_2O_7$)
300	24	Bluegills	Tlm		1 (Na_2CrO_4)
520	5-12	Young Eels	Killed		1 (K_2CrO_4)
0.016		Daphnia Magna	Toxic Threshold		1 ($Na_2Cr_2O_7$)
0.05	264	Daphnia Magna	Killed		1
<0.10		Daphnia Magna	Toxic Threshold		1 ($Na_2Cr_2O_7$)
<0.10		Daphnia Magna	Toxic Threshold		1 (Na_2CrO_4)
0.21		Protozoan (Microregma)	Threshold Effect		1 ($K_2Cr_2O_7$)
0.21		Diatom (Navicula)	Tlm	22°C, Softwater	1 ($K_2Cr_2O_7$)
0.25		Diatom (Navicula)	Tlm	22°C, Hardwater	1 ($K_2Cr_2O_7$)
0.51		Daphnia Magna	Toxic Threshold		1 (Na_2CrO_4)
0.7		Daphnia	Threshold Effect		1 ($K_2Cr_2O_7$)
0.7		Scenedesmus	Threshold Effect		1 ($K_2Cr_2O_7$)
0.7		E. Coli	Threshold Effect		1 ($K_2Cr_2O_7$)
1.4		Gammarus Pulex	Total Mortality		1 (Na_2CrO_4)
17.3		Snail	Tlm	20°C, Softwater	1 ($K_2Cr_2O_7$)
25.0		Midge Fly Larvae	Not Toxic		1
40.6		Snail	Tlm	20°C Hardwater	1 ($K_2Cr_2O_7$)
148		Polycelis Nigra	Toxic Threshold		1 (CrO_3)

ppm	hrs	species	resp	cond	ref
Salt Water Toxicity					
17.8		Silver Salmon	Toxic		1
500	168	Mummichogs	Tolerated		1

Mammalian

species	mg/kg B. W.	administration route	ref
Rabbit	[illegible]	Intravenous - Low Lethal Dose	[illegible]
Human	[illegible]	Oral - Low Lethal Dose	[illegible]

POTASSIUM DICHROMATE

Potassium dichromate is employed in lithography, photoengraving, pyrotechnics, tanning, ceramics, and the production of matches, batteries and chemicals. The 6.2 million lbs produced in 1959 (100) were shipped in metal and fiber drums, multiwall bags, tank cars, and tank trucks.

Potassium dichromate is a soluble oxidizing agent which forms an acid solution. A 10 percent solution has a pH of 3.57. As natural dilution neutralizes a spill, the dichromate will rapidly shift to chromate. The chromate ion is quite stable in the type of environment common to natural waters as is the potassium ion. Under anaerobic conditions, the chromate could possibly be reduced. Potassium dichromate can interfere with normal biochemical systems in water. A concentration of 100 ppm is sufficient to reduce oxygen utilization in sewage 50 percent (1).

Potassium dichromate is toxic to most aquatic life. Fish are affected in the range 10-150 ppm (1). The 96 hr TLm for fathead minnows is reported as 17.6 ppm in soft water and 27.3 in hardwater while those for bluegill are 110 and 133 ppm, respectively. (76) The threshold for various fish food organisms ranges from 0.016 to 40.6 ppm (1). Phosynthetic action in giant kelp is reduced 50 percent when exposed to 5 ppm chromium (1). In general, safe limits for chromium in water are 1 ppm for fish, and .05 ppm for other aquatic life (1). Solution pH, temperature, hardness, and dissolved oxygen content are all critical parameters in determining resultant toxicity. Salt water species appear to be as sensitive to chromate as freshwater species, although mummichogs have been shown to tolerate 200 ppm (1). Aquatic life can concentrate chromium. Algae has been found to concentrate it by a factor of 100-500 while trout can accumulate chromate from water when present at levels as low as 1 ppb (1).

Potassium dichromate is highly toxic when ingested or inhaled. An oral dose of 10 gms can be fatal to man in 35 min (8). Dogs fed 2829 mg/kg body weight died soon after (56). A concentration of 300 mg/l was toxic to rats when administered in drinking water (56). Humans administered 10 mg/l in drinking water showed no ill effects beyond vomiting (56). Drinking water should not contain more than .05 ppm chromium (1), as should water for livestock (42).

Potassium dichromate is an irritant. Water for body contact should not contain more than 1 ppm (40) and concentrations in water for prolonged contact should not exceed .05 ppm chromium (1).

Chrome dusts are quite hazardous if inhaled. Carcinoma may result from breathing chromate salt dusts (8). A TLV of 0.1 mg/m^3 has been established.

Chromate can be toxic to plants. Irrigation water should not contain more than 5 ppm chromium (42). Plants such as barley can absorb chromium into their structures.

Potassium dichromate can be tasted in water at the 1.5 ppm level (1).

NAME Potassium Dichromate

PRODUCTION QUANTITY 6.2 million lbs 1959 (198)

SYNONYMS Potassium Bichromate

COMMON SHIP OR CONTAINER SIZE Metal and fiber drums, multiwall bags, tank cars, tank trucks

M.P. 398. °C

B.P. 500. ° C Decomposes

Sp.G. 2.69

SOLUBILITY 49,000 mg/l at 0 °C

PERSISTENCE

Chemical Hydrolysis, etc.

Dichromate shifts to chromate in neutral or alkaline solutions.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
280	96	Mosquito Fish	Tlm	21-23°C	1
60	48	Hydropsyche	Tlm	Soft	169
3.5	48	Stenonema	Tlm	Soft	169
330	96	Bluegill	Tlm	High & Low Oxygen	170
706	24	Carp	Tlm	Lake	59
.4	96	Daphnia Magna	Tlm	Lake	59
730	24	Bluegill	Tlm	Lake	59
180	48	Brachydanio (adults)	Tlm	24C	139
1500	48	Brachydanio (eggs)	Tlm	24C	139
440	48	Bluegill	Tlm	24C	139
1	96	Fathead Minnow	Tlm	Soft	76
27.3	96	Fathead Minnow	Tlm	Hard	76
118	96	Bluegill	Tlm	Soft	76
133	96	Bluegill	Tlm	Hard	76
37.5	96	Goldfish	Tlm	Soft	76
30	96	Guppy	Tlm	Soft	76
.208	96	Nitzschia Linearis	Tlm		138
17.3	96	Physa heterostropha	Tlm		138
113	96	Bluegill	Tlm		138

ppm	hrs	species	para	cond	ref
5		Fish	Toxic		1
5.2		Brown Trout	Toxic		1$(K_2Cr_2O_7)$
7.1		Carp	Not Harmed		1$(K_2Cr_2O_7)$
9		Fish	Toxic Limit		1(CrO_3)
10			Only Slightly Hazardous		1$(Na_2Cr_2O_7)$
10		Silver Salmon	Fresh Water, Toxic		1
20		Rainbow Trout	Toxic	18°C	1$(K_2Cr_2O_7$ & $K_2CrO_4)$
35.5		Goldfish	Not Harmed		1$(K_2Cr_2O_7)$
45	480	Bluegills	Tolerated	Hard Water	1$(K_2Cr_2O_7)$
50	33	Trout	Killed		1$(K_2Cr_2O_7)$
50	720	Bluegills	Tolerated	Hard Water	1
52	50	Young Eels	Tolerated		1$(K_2Cr_2O_7)$
52	.5	Goldfish	Toxic		1(CrO_3)
52	96	Goldfish	Survived		1(CrO_3)
60	120	Bluegills	Tolerated	Hard Water	1$(K_2Cr_2O_7)$
70	168	Bluegills	Toxic Limit		1
75	96	Bluegills	Died		1$(K_2Cr_2O_7)$
81	240	Bluegills	Tolerated		1$(K_2Cr_2O_7)$
100	24	Trout	TLm		1(K_2CrO_4)
100	6	Trout	Fatal		1$(K_2Cr_2O_7)$
103	65	Bluegills	TLm		1$(K_2Cr_2O_7)$
104	6-84	Goldfish	Toxic		1(CrO_3)
110	96	Sunfish	TLm		1$(K_2Cr_2O_7)$
113		Sunfish	TLm		1$(K_2Cr_2O_7)$
130	50	Young Eels	Tolerated		1$(K_2Cr_2O_7)$
135	96	Sunfish	TLm	Hard Water	1$(K_2Cr_2O_7)$
145	24	Bluegills	TLm		1$(Na_2Cr_2O_7)$
148		Bluegills	Toxic Limit		1$(Na_2Cr_2O_7)$
170	96	Sunfish	TLm		1(K_2CrO_4)
177	72	Goldfish	Toxic		1$(K_2Cr_2O_7)$
180-362		Several Species	Toxic		1
196		Large-Mouth Bass	TLm		1
213	48	Bluegills	TLm		1$(Na_2Cr_2O_7)$
300	24	Bluegills	TLm		1(Na_2CrO_4)
520	5-12	Young Eels	Killed		1(K_2CrO_4)
0.016		Daphnia Magna	Toxic Threshold		1$(Na_2Cr_2O_7)$
0.05	264	Daphnia Magna	Killed		1
<<0.10		Daphnia Magna	Toxic Threshold		1$(Na_2Cr_2O_7)$
<<0.10		Daphnia Magna	Toxic Threshold		1(Na_2CrO_4)
0.21		Protozoan (Microregma)	Threshold Effect		1$(K_2Cr_2O_7)$

ppm	hrs	species	resp	cond	ref
0.21		Diatom (Navicula)	TLm	22°C, Softwater	1(RgCrgOy)
0.25		Diatom (Navicula)	TLm	22°C, Hardwater	1(RgCrgOy)
0.35		Daphnia Magna	Toxic Threshold		1(MagCrOg)
0.7		Daphnia	Threshold Effect		1(RgCrgOy)
0.7		Scenedesmus	Threshold Effect		1(RgCrgOy)
0.7		E. Coli	Threshold Effect		1(RgCrgOy)
1.4		Gammarus Pulex	Total Mortality		1(MagCrOg)
17.3		Snail	TLm	20°C Softwater	1(RgCrgOy)
25.0		Midge Fly Larvae	Not Toxic		1
40.8		Snail	TLm	20°C Hardwater	1(RgCrgOy)
140		Polycelis Nigra	Toxic Threshold		1(CrOg)

Salt Water Toxicity

17.0		Silver Salmon	Toxic		1
200	168	Mummichogs	Tolerated		1

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	2020	lethal-oral	56

SODIUM CHROMATE

Sodium chromate is employed largely as a corrosion inhibitor. Sodium chromate is beginning to replace the potassium salt for many plating, anodizing and tanning uses. More than 300 million lbs of sodium chromate and dichromate were produced in 1970 (198) and shipped in metal and fiber drums, multiwall bags, tank cars, and tank trucks.

Sodium chromate is a readily soluble oxidizing agent that forms a solution alkaline to phenothalein. The chromate ion is quite stable in the type of environment common to natural waters as is the sodium ion. Under anaerobic conditions or in the presence of high organic loads the chromate could possibly be reduced. Sodium chromate can interfere with normal biochemical systems in water. A concentration of 1.0 ppm is sufficient to reduce oxygen utilization in sewage 10 percent.

Sodium chromate is toxic to most aquatic life. Fish are affected in the range 300-420 ppm (1). The 96 hr TLm for mosquito fish is reported as 420 ppm in turbid water (1), while the 24 hr value for bluegill is 300 ppm (1). The threshold for various fish food organisms ranges from 0.1 to 500 ppm (1,287). Photosynthetic action in giant kelp is reduced 50 percent when it is exposed to 5 ppm chromium (1). In general, safe limits for chromium in water are 1 ppm for fish and .05 ppm for other aquatic life (1). Solution pH, temperature, hardness, and dissolved oxygen content are all critical parameters in determining resulting toxicity. Salt water species appear to be as sensitive to chromate as fresh water species. A concentration of 40-60 ppm is toxic to shore crabs while 5 ppm affects young prawns (300). Aquatic life can concentrate chromium. Algae has been found to concentrate it by a factor of 100-500 while trout can accumulate chromate from water when present at levels as low as 1 ppb (1).

Sodium chromate is highly toxic when ingested or inhaled. The subcutaneous LD50 for rabbits is reported to be 243 mg/kg body weight (8). Rats fed 25/mg/l in drinking water for six months showed a drop in hemoglobin levels while mice given 5 ppm for life showed a decrease in survival and longevity (50). Humans tolerated 25 mg/l for three yrs. with no effects (50), but drinking water should not contain more than .05 ppm chromium (1), nor should water for livestock (42).

Sodium chromate is an irritant. Water for body contact should not contain more than 1 ppm (40) and concentrations in water for prolonged contact should not exceed .05 ppm chromium (1).

Chrome dusts are quite hazardous if inhaled. Carcinoma may result from breathing chromate salt dusts (8). A TLV of 0.1 mg/m^3 has been established.

Chromate can be toxic to plants. Irrigation water should not contain more than 5 ppm chromium (42). Plants such as barley can absorb chromium into their structures.

NAME Sodium Chromate

PRODUCTION QUANTITY 300 million lbs - 1970 Chromate and Dichromates

COMMON SHIP OR CONTAINER SIZE 100 lb fiber bags, metal drums, tank cars, tank trucks

M.P. 19.9 °C

Sp.G. 1.483

SOLUBILITY 317,000 mg/l at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
300	24	Bluegill	TLm		1
420	96	Mosquito fish	TLm	Turbid	1
<0.10		Daphnia Magna	Toxic Threshold		1
0.51		Daphnia Magna	Toxic Threshold		1
1.4		Gammarus Pulex	Total Kill		1
1-500		E. Coli	Toxic		287

Salt Water Toxicity

ppm	hrs	species	para	cond	ref
40-60	288	Shore Crabs	Toxic		288
5	288	Young Prawns	Toxic		288

Mammalian

species	mg/kg B.W.	administration route	ref
Rabbits	243	Subcutaneous	8

SODIUM DICHROMATE

Sodium dichromate is employed in dyeing, photoengraving, corrosion inhibition, tanning, textile finishing, and the production of inks, batteries and chemicals. The 300 million lbs of sodium chromate and dichromate produced in 1970 (198) were shipped in metal and fiber drums, multiwall bags, tank cars, and tank trucks.

Sodium dichromate is a soluble oxidizing agent which forms an acid solution. As natural dilution neutralizes a spill, the dichromate will rapidly shift to chromate. The chromate ion is quite stable in the type of environment common to natural waters as is the sodium ion. Under anaerobic conditions or with high organic loads, the chromate could possibly be reduced. Sodium dichromate can interfere with normal biochemical systems in water. A concentration of 100 ppm of the potassium salt is sufficient to reduce oxygen utilization in sewage 50 percent (1).

Sodium dichromate is toxic to most aquatic life. Fish are affected in the range 10-420 ppm (1). The 24 hr TLm for bluegill is reported as 145 ppm while the 48 hr value is 213 ppm (1). The threshold for various fish food organisms ranges from 0.016 to 22 ppm (1,59). Photosynthetic action in giant kelp is reduced 50 percent when exposed to 5 ppm chromium (1). In general, safe limits for chromium in water are 1 ppm for fish, and .05 ppm for other aquatic life (1).

Solution pH, temperature, hardness, and dissolved oxygen content are all critical parameters in determining resultant toxicity. Aquatic life can concentrate chromium. Algae has been found to concentrate it by a factor of 100-500 while trout can accumulate chromate from water when present at levels as low as 1 ppb (1).

Sodium dichromate is highly toxic when ingested or inhaled. A subcutaneous dose of 51 mg/kg body weight can be fatal to guinea pigs (55). A concentration of 25 mg/l lowered hemoglobin levels when administered to rats in drinking water (56). Humans can tolerate 25 mg/l in drinking water for three yrs with no ill effects (56). Drinking water, however, should not contain more than .05 ppm chromium (1), as should water for livestock (42).

Sodium dichromate is an irritant. Water for body contact should not contain more than 1 ppm (40) and concentrations in water for prolonged contact should not exceed .05 ppm chromium (1).

Chrome dusts are quite hazardous if inhaled. Carcinoma may result from breathing chromate salt dusts (8) for which a TLV of 0.1 mg/m^3 has been established.

Chromate can be toxic to plants. Irrigation water should not contain more than 5 ppm chromium (42). Plants such as barley can absorb chromium into their structures.

NAME Sodium Dichromate

PRODUCTION QUANTITY 300 million lbs - 1970 Chromate and Dichromates

SYNONYMS Sodium Bichromate, Bichromate of Soda

COMMON SHIP OR CONTAINER SIZE 100 lb bags, fiber or steel drums, tank cars, tank trucks

M.P. 150 °C loses water

B.P. 400 °C decomposes

Sp.G. 2.348

SOLUBILITY 2,380,000 mg/l at 0 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	mean	cond	ref
10		Fish	Slight Hazard		1
145	24	Bluegill	TLm		1
140		Bluegill	Toxic Limit		1
213	48	Bluegill	TLm		1
264	96	Mosquito fish	TLm	Turbid	1
0.016		Daphnia Magna	Toxic Threshold		1
<<0.10		Daphnia Magna	Toxic Threshold		1
420	48	Mosquito fish	TLm	Turbid	48
22	23	Daphnia Magna	TLm		59

Mammalian

species	mg/kg B.W.	administration route	ref
Guinea Pig	81	Subcutaneous--Lethal Dose	83
Rat	160	Intramuscular - Low Toxic Dose	84

Strontium Chromate

Strontium chromate is employed in pigments. The yellow crystalline solid is soluble to 1200 ppm in water and dissociates on dissolution. The carbonate and sulfate salts of strontium are only slightly soluble and will precipitate. The chromate can persist unless reducing conditions prevail. The aquatic toxicity of strontium chromate will arise from that of the chromate ion.

STRONTIUM CHROMATE

Sp. G. - 3.895

SOLUBILITY - 1200 ppm in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates on dissolution. Carbonate and sulfate salts of strontium only slightly soluble. Chromate can persist unless reducing conditions prevail.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the chromate anion.

ZINC DICHROMATE

SYNONYMS - Zinc Dichromate

SOLUBILITY - Very soluble in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - Will dissociate in water. Zinc may be precipitated as the carbonate or hydroxide salt. Dichromate ion is relatively stable but can under reducing conditions be reduced to a trivalent chromic ion.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for the zinc ion.

COBALT

Cobalt and its salts are used for making alloys, in nuclear technology, as pigment in the china and glass industry, and as binders in the tungsten carbide tool industry. The more common chloride, nitrate, and sulfate salts are shipped in bottles and drums.

Most cobalt salts are readily soluble in water, and will form a blue solution when spilled. Cobalt cations form acid solutions because of the insolubility of their hydroxide and carbonate salts. After the initial spill, dilution will begin to cause carbonate, hydroxide, and phosphate (if available) precipitates to form and settle to the bottom. Turbid waters can be expected for some time to come. While the cobaltous (Co^{+2}) form is quite stable, cobaltic ion (Co^{+3}) is a powerful oxidizing agent which will not persist in natural waters. The cobalt that remains in solution can affect natural oxygen utilization. Concentrations of cobalt as low as 23-29 ppm will bring about 50 percent inhibition of sewage organisms (1).

While cobalt in trace quantities is essential to life, it can be lethal to fish at low concentrations. Stickleback have been killed by concentrations as low as 22 ppm in tap water (1). A level of 10 ppm cobalt is considered the lethal concentration for stickleback (1). Fish food organisms are affected by cobalt concentrations as low as 0.5 ppm (1). Hardness appears to be a critical parameter. Microorganisms can concentrate cobalt in water up to 1,070-1,500 times (1).

Cobalt is tolerated at different levels by various species of mammals (1). An LD50 for rats fed cobalt chloride has been reported as 300 mg/Kg body weight (56). When cobalt is fed to rats at greater than 0.9 mg/kg, toxic effects occur. A dose of 2 mg cobalt/day is lethal (1). Concentrations of 100 mg/l in water can cause tissue damage; 200 mg/l is lethal (1). No drinking water limits can be set with the existing data, but it is known that .25 mg/day can effect the hemoglobin in human blood (1). Doses of 10-15 grains can cause severe symptoms, and may be fatal (56). Chronic feeding of 5 mg/day for 10 mos caused anemia in lambs, while 1.1 mg/Kg body weight/day led to blood changes in cattle (56).

Cobalt has known phytotoxic properties. 0.1-2.7 mg/l can injure tomatoes. A concentration of 2 mg/l can stunt plants, and 10.7 mg/l can cause death (1). Irrigation water should never carry more than 10 ppm cobalt and should not contain more than .2 ppm cobalt for any sustained period (42).

COBALTOUS BROMIDE

M.P. 678°C (anhydrous)

Sp. G. = 4.909

SOLUBILITY = 667,000

PERSISTENCE

Chemical Hydrolysis, etc. - Cobalt ions are precipitated as hydroxide and carbonate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for cobalt ions in general.

COBALTOUS FLUORIDE

M.P. 1100 - 1200°C

B.P. - Volatilises at 1400°C

Sp. G. - 4.43

SOLUBILITY - Sparingly soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Cobalt ion will be precipitated as the hydroxide and carbonate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for fluoride ion in general.

Saltwater Toxicity - Toxicity will be that for cobalt ion in general.

COBALTOUS FORMATE

M.P. - Becomes anhydrous at 140°C

B.P. - Decomposes at 175°C

Sp. G. - 2.13

SOLUBILITY - 50,300

PERSISTENCE

Chemical Hydrolysis, etc. - Cobalt ion precipitates as hydroxide and carbonate salts. Formate ion is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for cobalt ion in general.

COBALT SULFAMATE

Sp. G. - >1.0

SOLUBILITY - Soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Cobalt ion will precipitate as hydroxide carbonate salt.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of cobalt ion in general.

COPPER

Low levels of copper occur in natural water, generally below 20 mg/l in fresh water. Copper is found in seawater at a concentration of about 3 mg/l (42). Higher levels are usually the result of industrial effluents or the use of copper for vegetation control in water supply reservoirs. Uses for copper salts also include textile finishing, pigmentation, tanning, photography, engraving, and electroplating. Most of the copper salts are shipped by rail and truck.

Common copper salts (chloride, nitrate, and sulfate) are very soluble in distilled water. The solubility of copper in natural water is greatly dependent on water quality characteristics. In natural water three physical states are possible: particulate, colloidal, and soluble (295). Bryan reports a concentration of 0.4-0.8 mg/Cu/l in a saturated solution of aerated seawater (246). Copper salts give an acid reaction in water with the precipitation of insoluble oxides. Excessive amounts will drive the pH down markedly. Copper salts may interfere with normal stream biological activity. A concentration of 8.4-16 ppm is sufficient to inhibit oxygen utilization of sewage 50 percent (1). McDermott et al. found that the maximum concentration of copper that did not have a detectable effect on treatment efficiency of a pilot activated sludge treatment plant was 1 mg/l (295).

The toxicity of copper to aquatic life varies greatly with species and water quality characteristics: hardness, alkalinity, pH, phosphates, and complexing agents such as amino acids, polypeptides, and humic substances. Copper may be present in polluted water associated with suspended solids, and in different soluble chemical states. The resulting toxicity is dependent on these different forms of copper. Pickering and Henderson found that for four species of fish tested in soft water (20 mg/l $CaCO_3$), the 96 hr TL50 values varied from 23 µg/l for the fathead minnow to 660 µg/l for the bluegill (250). Mount reported a 96 hr TL50 value for the fathead minnow of 470 µg/Cu/l in a continuous flow bioassay using hard water (200 mg/l $CaCO_3$) (297). In the chronic study, 33 µg/l had a detrimental effect on egg production and no detrimental effects were demonstrated at 15 µg/l. Mount and Stephan found a 96 hr TL50 value of 75 µg/l in soft water (30 mg/l $CaCO_3$) and in the chronic study, 18 µg/l had a detrimental effect on egg production and 11 µg/l was "safe" (298). McKim and Benoit reported a 96 hour TL50 value of 100 µg/l for brook trout in soft water (45 mg/l $CaCO_3$) (299). In the chronic study, 10 µg/l was "safe", and 17 µg/l was detrimental. Sprague, et al., found that Atlantic salmon avoid a concentration of about 0.004 mg/l in soft water (20 mg/l $CaCO_3$) (300). Arthur and Leonard reported that the average TL50 for three species of aquatic invertebrates tested in soft water (45 mg/l $CaCO_3$) varied from 1.7 to 0.02 mg/l (301). Biesinger and Christensen reported 48 hr LC50 values of

9.8 µg/l for Daphnia magna in Lake Superior water (45 mg/l $CaCO_3$) and 60 µg/l in Lake Superior water with food added (252). In the chronic study, 35 µg/l caused a 50 percent reproductive impairment while 22 µg/l was "safe". The estimated 96 hr TLm for oysters is reported to be 1.4 ppm copper (1).

Lucas et al. reported that in whole fish copper varied from 0.8 to 2.7 ppm (273). In fish liver the concentration averaged 9 ppm and varied from 1.5 to 14 ppm (wet weight). Uthe found that copper concentrations in dressed fish varied from 0.5 to 1.28 ppm (240). Windom and Smith reported copper concentrations in oysters varied from 48 to 461 ppm (dry weight) (302).

Copper is an essential element in human metabolism. The daily requirement for adults has been estimated to be 2 mg. Pre-school children require about 0.1 mg daily for normal growth. Large doses in man may produce emesis, and prolonged oral administration may result in liver damage. Copper imparts an undesirable taste in drinking water.

Copper salts can be highly toxic if ingested. Oral LD50 values for rats have been reported as 140 mg/kg body weight (85), 940 mg/kg (77), and 300 mg/kg (8) for the chloride, nitrate, and sulfate, respectively.

Small amounts of copper are beneficial or essential for plant growth; however low concentrations can be toxic. Copper has been used for years for controlling algae which cause taste and odors in water supply reservoirs. Copper is toxic at a concentration of 0.1 mg/l to orange and mandarin seedlings and at 0.17 to 0.20 mg/l to sugar beets and barley grown in nutrient solutions (1).

As little as 0.1 mg/l copper can inhibit photosynthesis in giant kelp 50 percent in 3-5 days and 70 percent in 7-9 days (1).

CUPRIC ACETATE

SYNONYMS - Copper Acetate, Neutral Verdigris, Crystallized Verdigris, Crystals of Venus

M.P. 115°C

B.P. - Decomposes at 240°C

Sp. G. - 1.9

SOLUBILITY - 72,000

PERSISTENCE

Chemical Hydrolysis, etc. - Copper precipitates as a hydrous oxide. Acetate ion is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for copper in general.

Mammalian Toxicity

Species	mg/Kg B. W.	Administration Route	Ref
Rat	710	Oral	96

CUPRIC ACETOARSENITE

SYNONYMS - Copper Acetate Arsenite, Emerald Green, French Green, Imperial Green, Mineral Green, Mitis Green, Paris Green, Parrot Green, Schweinfurt Green, Vienner Green

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

Sp. G. - >1.0

SOLUBILITY - Practically insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Does not persist upon residence in water. Copper is likely to ultimately be found as precipitated hydrous oxide.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that of copper ion.

ppm	Hrs	Species	Form	Cond.	Ref.
1.5 lb/acre	-	Mosquito Larvae	Effective Control	Field	1

Mammalian Toxicity

Species	mg/Kg B. W.	Administration Route	Ref
Rat	22	Oral-Low Lethal Dose	56
Rat (female)	100	Oral	1

NAME Cupric Chloride

PRODUCTION QUANTITY 47 million lbs

SYNONYMS Copper Chloride

M.P. 498 °C decomposes

B.P. 993 °C decomposes

Sp.G. 3.38

SOLUBILITY 1,100,000 mg/l at 25°C

PERSISTENCE

Chemical Hydrolysis, Etc.

Oxides are relatively insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
0.009 (As Cu)		Goldfish	Rapid Death		1
0.13	50	Eels	Threshold		1
0.0188	3.5-7	Goldfish	Killed	Distilled	1
672	1.2	Minnows	Killed	Distilled	1
1.25	96	Bluegill	TLm	Soft, 18-20 °C	1
5	10	Rainbow Trout	Death	Lake Huron	1
5	12	Sea Lamprey	Death	Lake Huron	1
5	24	Bluegill	Death	Lake Huron	1
.98	96	Bluegill	LC50	55-75°F	103
.795-.815	120	Nitzchia Linearis	TLm		138
0.1-1.0		Most Fish	Not Toxic		1
0.015-3.0		Some Fish, Crustacea, Mollusca, Insects, Phytoplankton, Zooplankton	Immobilization	Lake Erie	1
1.5 (Cu)	48-72	Nereis Sp.	Toxicity Threshold		288
15 (Cu)	96	Nereis Sp.	Toxicity Threshold		288
1-2 (Cu)		Shore Crab	Toxicity Threshold		288
.5 (Cu)		Prawns	Toxicity Threshold		288

ppm	hrs	species	parm	cond	ref
.034(Cu)	24	Atlantic Salmon	TLm	2 ug/l Zn	304
.8(Cu)	24	Rainbow Trout	TLm	River	265
.02(Cu)		Stickleback	Toxic Limit		305
3.0(Cu)	96	Crayfish Intermolt	TLm	20 °C	306
1.0(Cu)	24	Crayfish Adult	TLm	20 °C	306
1.0(Cu)	144	Crayfish Juvenile	TLm	20 °C	306
1.0(Cu)	144	Crayfish Recent Hatches	TLm	20 °C	306
1.0(Cu)		Lebistes Reticulatus	Killed		82
0.1(Cu)		Bufo Valliceps	Killed		82
0.1(Cu)		Daphnia Magna	Killed		82
.43(Cu)	96	Fathead Minnow	TLm		297
.4-.5(Cu)	48	Rainbow Trout	TLm		158
1.25	96	Bluegill	TLm		16

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
0.56		Fish & Aquatic Life	Min. Lethal Con.		1
10-30	2	Barnacles & Related Species	Killed		1
0.22-1.0	48-240	Barnacles & Related Species	Killed		1
0.2-0.3		Barnacles & Related Species	Inhibited Growth		1
0.55	12	Mussel	Killed		1
Cu. Lined Tank	24	Lobsters	Killed		1
0.1-0.5		Bacteria & Microorganisms	Toxic		1
0.1	48-120	Giant Kelp	Inhibits Photosynthesis 50%		1
0.1	168-336	Giant Kelp	Inhibits Photosynthesis 70%		1
0.1	240	Giant Kelp	Visible Injury		1
0.1-0.5		Oysters	Toxic		1
1.9	96	Oysters	TLm		1
0.02		Fish & Aquatic Life	Threshold Beneficial Effects		1

Mammalian species	mg/kg B.W.	Administration route	ref
Rat	140	Oral	85

CUPRIC FORMATE

Sp. G. - 1.831

SOLUBILITY - 125,000

PERSISTENCE

Chemical Hydrolysis, etc. - Copper will precipitate as an hydrous oxide. The formate ion is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for copper ion.

CUPRIC GLYCINATE

SYNONYMS - Bis (glycinato) Copper, Cupric Aminoacetate, Glycine Copper Complex, Glycocoll-Copper

M.P. - Loses H_2O at 140°C

B.P. - Decomposes at 228°C

SOLUBILITY - 5700

PERSISTENCE

Chemical Hydrolysis, etc. - Copper will eventually precipitate as hydrous oxide while the organic fraction biodegrades.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for copper ion.

CUPRIC LACTATE

Sp. G. - ~1.0

SOLUBILITY - 167,000

PERSISTENCE

Chemical Hydrolysis, etc. - Copper will precipitate as an hydrous oxide. Lactate ion is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for copper ion.

NAME Cupric Nitrate

SYNONYMS Copper Nitrate

M.P. 114.5 °C

B.P. 170 °C loses HNO_3

Sp.G. 2.32

SOLUBILITY 1,378,000 mg/l at 0 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Oxides are relatively insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	TERM	COND	REF
0.015		Sticklebacks	Lethal Con. Limit	15-18°C	1
0.06	96	Sticklebacks	Survival Time		1
0.3(Cu)	24	Sticklebacks	Survival Time		1
0.18(Cu)		Sticklebacks	Min. Lethal Con.		1
0.178	-66	Young Pink Salmon	Loss of Equilibrium, Some Deaths		1
0.10		Young Pink Salmon	Long Term Dangerous Con.		1
5	11	Rainbow Trout	Death	Lake Huron	1
5	13	Sea Lamprey	Death	Lake Huron	1
5	24	Bluegill	No Effect	Lake Huron	1
0.0188		Tadpoles	Death	Tap	1
1.5(Cu)	48-72	Nereis Sp.	Toxicity Threshold		288
15(Cu)	96	Nereis Sp.	Toxicity Threshold		288
1-2(Cu)		Shore Crab	Toxicity Threshold		288
.5(Cu)		Prawns	Toxicity Threshold		288
.034(Cu)	24	Atlantic Salmon	TLm	2 ug/l Zn	304
.8(Cu)	24	Rainbow Trout	TLm	River	265
.02(Cu)		Stickleback	Toxic Limit		305

ppm	hrs	species	resp	cond	ref
1.0(Cu)	96	Crayfish Intermolt	TLm	20 °C	106
1.0(Cu)	24	Crayfish Adult	TLm	20 °C	106
1.0(Cu)	44	Crayfish Juvenile	TLm	20 °C	106
1.0(Cu)	144	Crayfish Recent Hatches	TLm	20 °C	106
1.0(Cu)		Lebistes Reticulatus	Killed		83
0.1(Cu)		Bufo Valliceps	Killed		83
0.1(Cu)		Daphnia Magna	Killed		83
.43(Cu)	96	Fathead Minnow	TLm		207
.4-.5(Cu)	48	Rainbow Trout	TLm		158
1.25	96	Bluegill	TLm		16

Salt Water Toxicity

ppm	hrs	species	resp	cond	ref
0.56		Fish & Aquatic Life	Min. lethal Con.		1
10-30	2	Barnacles & Related Species	Killed		1
0.22-1.0	48-240	Barnacles & Related Species	Killed		1
0.2-0.3		Barnacles & Related Species	Inhibited Growth		1
0.55	12	Mussel	Killed		1
Cu. lined Tank	24	Lobsters	Killed		1
0.1-0.5		Bacteria & Microorganisms	Toxic		1
0.1	48-120	Giant Kelp	Inhibits Photosynthesis 50%		1
0.1	168-316	Giant Kelp	Inhibits Photosynthesis 70%		1
0.1	240	Giant Kelp	Visible Injury		1
0.1-0.5		Oysters	Toxic		1
1.9	96	Oysters	TLm		1
0.02		Fish & Aquatic Life	Threshold Beneficial Effects		1

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	940	Oral	77

NAME Cupric Oxalate

SOLUBILITY 25 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Copper may precipitate as hydrous oxide as biochemical oxidation degrades oxalate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for the copper ion in general.

CUPRIC SUBACETATE

SYNONYMS - Copper Acetate Basic, Cupric Acetate Basic, Common Verdigris, Green Verdigris, Blue Verdigris, French Verdigris

Sp. G. - 1.9

SOLUBILITY - Slightly soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Slowly decomposed by water. Likely to ultimately reside as precipitated hydrous copper oxides. Acetate is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for the copper ion in general.

NAME Cupric Sulfate

PRODUCTION QUANTITY 67 million lb

SYNONYMS Copper Sulfate, Blue Vitriol, Chalcanthite

M.P. 110 °C loses water

B.P. 150 °C loses more water

Sp.G. 2.285

SOLUBILITY 316,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Oxides are insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
<5.		Cladophora Sp.	Morphological Change		312
10	96	Cladophora Sp.	Died		312
1.7	96	Campeloma Decisum	TLm	Continuous Flow Soft	313
0.039	96	Physa Integra	TLm	Continuous Flow Soft	313
0.020	96	Gammarus Pseudolimnaeus	TLm	Continuous Flow Soft	313
0.008-0.0148	864	Amphipods	No Effect	Continuous Flow Soft	313
4.7	40	Aspergillus Niger	LD50	Temp. 32°C	216
.008-.015		Yearling Brook Trout	Altered Feeding Response		180
1.5	24	Striped Bass	LC50		22
.15	48	Bluegill	LC50		22
.14		Trout	Highest Tolerable Con.		22
.33		Carp	Highest Tolerable Con.		22
.33		Suckers	Highest Tolerable Con.		22
.40		Catfish	Highest Tolerable Con.		22

MnO_4

ppm	hrs	species	param	cond	ref
.40		Pickerel	Highest Tolerable Con.		22
.50		Goldfish	Highest Tolerable Con.		22
.67		Perch and Bluegill	Highest Tolerable Con.		22
.80		Largemouth Bass	Highest Tolerable Con.		22
1.35		Sunfish	Highest Tolerable Con.		22
2.00		Smallmouth Bass	Highest Tolerable Con.		22
.6	48	Bluegill	LC50	Hardness 15 ppm	22
6.0	48	Bluegill	LC50	Hardness 60 ppm	22
10.0	48	Bluegill	LC50	Hardness 100 ppm	22
45.0	48	Bluegill	LC50	Hardness 182 ppm	22
75	96	Mosquito fish	TLm	Turbid, 24-27°C	1
.47	48	Polycelis Nigra	Killed	Lake	1
.01	48	Daphnia	Killed	Lake	1
1	48	Planarium Worm	Killed		1
3.6	24	Rainbow Trout	TLm	Stream	107
1		Golden Shiner	Lethal	Pond	108
1.4	96	Bluntnose Minnow	TLm	Hard	239
0.05	96	Bluntnose Minnow	TLm	Soft	239
16		Frog	Lethal		109
.5	5-20 Day	Microlife	95% Growth Reduction		110
11		Bluegill Eggs	Lethal	Lakes	111

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
.14	48	Prawn	LC50	Aerated	2
39.5	48	Shrimp	LC50	Aerated	2
19	48	Shrimp	LC50	Aerated	2
1	48	Cockle	LC50	Aerated	2
1-1.3	48	Flounder	LC50	Aerated	2
109	48	Crab	LC50	Aerated	2
100	48	Oyster	LC50	Aerated	2

[illegible]

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	300	Oral	8
Rabbit	50	Oral-10 [illegible]	78

CUPRIC SULFATE, AMMONIATED

SYNONYMS - Copper Ammonium Sulfate, Cupric Ammine Sulfate

M.P. - Decomposes at 150°C

Sp. G. - 1.81

SOLUBILITY - 185,000

PERSISTENCE

Chemical Hydrolysis, etc. - May release ammonia while present in water. Neutralization leads to precipitation of hydrous copper oxides.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for copper ion.

CUPRIC TARTRATE

Sp. G. = >1.0

SOLUBILITY - [illegible]

PERSISTENCE

Chemical Hydrolysis, etc. - Copper will precipitate as an hydrous oxide. Tartrate is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of copper ion

CUPROUS BROMIDE

M.P. 504°C

B.P. 1345°C

Sp. G. - 4.72

SOLUBILITY - Very slightly soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Cuprous ions oxidize to the more stable cupric form and are precipitated as hydrous oxides.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for copper ions.

COUMAPHOS

Coumaphos or Co-Ral is an animal insecticide and nematocide commonly used to control ticks, lice, flies and grubs in cattle as well as screwworms in all livestock. It is also used in chicken feed under the trade name Meldane. It is commonly formulated as a 25 percent wettable powder, 4 percent pour on, 1 pound-1 gallon emulsifiable concentrate, 5 percent dust, and feed premix.

Coumaphos is not one of the more persistent halogenated organic pesticides. Its structure is a naphthalene analog which is more degradable than some of the DDT type compounds. Coumaphos hydrolyzes slowly under alkaline conditions and is soluble to only 1.5 ppm unless formulated in a wettable form. Upon spillage, it is likely to sink and spread through the bottom sediments where much of it will absorb and slowly degrade through biochemical action.

Coumaphos is quite toxic to aquatic organisms. The 96 hour TLm values for fathead minnow, bluegill, and rainbow trout have been reported as >18 ppm, .18 ppm and 1.5 ppm respectively.[illegible] Alabaster[illegible] reports much greater sensitivity in harlequin fish where the 24 hour LC_{50} value is reported as 0.082 ppm. Similarly, 48 hour LC_{50} values for the common food chain organisms, Daphnia magna and Gammarus lacustris, are reported as 1.0 and 0.14 ppm respectively.[illegible] In salt water, Davis, et al.,[illegible] describe 48 hour TLm values of 9.12 ppm and 0.11 ppm for clam and oyster eggs respectively.

In mammals, oral toxicity is moderate. Male rats display characteristic LD_{50} responses in the range [illegible] mg/kg body weight,[illegible] while similar values for females are [illegible] mg/kg body weight.[illegible] The oral LD_{50} for young mallard ducks is reported as [illegible] mg/kg body weight.[illegible]

COUMAPHOS

SYNONYMS - CoRal, O,O-Diethyl O-3-chloro-4-methyl-2-oxo-2,4-1-
benzopyran-7-yl-phosphorothioate, 3-chloro-4-methylumbelliferone,
O, O-diethyl O-(3-chloro-4-methyl-7-coumarinyl) phos-
phorothioate, Asuntol, Bayer 21/199, Muscatox, Resitox,
Meldane

M.P. 91°C

Sp. G. - 1.474

SOLUBILITY - 1.5 ppm

PERSISTENCE

Oxygen Removal - Coumaphos is moderately persistent

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Param	Cond.	Ref.
					22
0.082	24	Harlequin Fish	LC_{50}		22
1.0	48	Daphnia Magna	LC_{50}		22
0.14	48	Gammarus Lacustris	LC_{50}		22
0.32	24	Gammarus Lacustris	LC_{50}		
>10	96	Fathead Minnow	TLm	As Active Ingredient	189
0.18	96	Bluegill	TLm	As Active Ingredient	189
15	96	Coho Salmon	TLm	In Acetone	402
1.5	96	Rainbow Trout	TLm	In Acetone	402
1.862	96	Threespine Stickleback	TLm	In Acetone	402
					402
0.5	36	Smallmouth Bass	LT_{50}		402
0.5	72	Fathead Minnow	LT_{50}		
18	96	Goldfish	TLm	Soft-Acetone Or Alcohol Solvent	402
0.56	96	Guppy	TLm	Soft-Acetone Or Alcohol Solvent	402
0.39	24	Chaoborus Astictopus	TLm	Fourth Instar Larvae	179
0.28	48	Longnose Killifish	EC_{50}	12°C	25
0.55	48	Rainbow Trout	TLm		177
0.73	48	Brown Trout	TLm		177
0.8	48	Brook Trout	TLm		177
4.0	48	Lake Trout	TLm		177

ppm	hrs	Species	Parm	Cond.	Ref.
6.8	24	Channel Catfish	Tlm		177
8.0	48	Bluegill	Tlm		177
0.43	24	Hexagenia Sp.	Tlm	Mississippi River	402
0.005	24	Hydropsyche Sp. (Larvae)	Tlm	Mississippi River	402
1.4	24	Bluegill	Tlm	Mississippi River	402
0.046	48	Harlequin Fish	Tlm		409
62	96	Striped Bass (Fingerling)	Tlm		410

Saltwater Toxicity

9.12	48	Hard Clam (Eggs)	Tlm		411
5.21	288	Hard Clam (Larvae)	Tlm		411
0.11	48	Oyster (Eggs)	Tlm		411
>1.0	336	Oyster (Larvae)	Tlm		411

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat (Male)	56-230	Oral	73
Rat	41	Oral	96
Rat (Female)	13-30	Oral	127

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	29.6	Oral	22
Pheasants	300-400 ppm	LC_{50} - 5 days	22
Coturnix	200-250 ppm	LC_{50} - 5 days	22
Chicken	100	Leg Weakness	22

CRESOL

Cresol is produced in three isomeric forms and as a mixture. It is used in fumigants, explosives, phenolic resins, and wood preservatives. The 81.2 million lbs produced in 1970 (198) were shipped in bottles, cans, carboys, barrels, drums, tank cars, and tank trucks.

Cresol has a limited solubility in water. If spilled, it will sink to the bottom and slowly dissolve. In the aqueous phase it acts much as its phenol forebearer. Phenols form a weakly acidic solution and are highly reactive in various situations. In the presence of acids, they undergo addition reactions such as nitration when placed in dilute nitric acid. Phenols will also pick up chlorine very rapidly to form far more objectionable compounds. Perhaps most pertinent of its aqueous reactions is oxidation. Phenols, especially in alkaline solutions, are readily oxidized to form a complex mixture of products, including quinone and phenoquinone when the oxidant is air. Cresol is also known to darken when exposed to light. This type of photodegradation may not be important after cresol has entered water.

Dissolved cresol is also subject to biodegradation. Up to 1.7 lb of oxygen per lb of cresol can be consumed in the first five days (11). This degradation may well be rapid enough to lead to localized oxygen deficiencies in a spill situation. When too concentrated, however, the cresol will inhibit bacterial action. A concentration of 940 ppm is sufficient to cause 50 percent inhibition of sewage organisms.

The aquatic toxicity of cresol has been examined by many investigators. The toxic threshold for most fish lies between 20 and 40 ppm (1). Fish food organisms are sensitive to levels as low as 6 ppm (1). Phenolics in general have a toxic threshold of 1 ppm to fish (41). The meta isomer appears the least toxic of the three. Oxygen content is critical to toxicity. Low oxygen levels can cause a dramatic drop in the toxicity of cresols (1). A concentration of 140 ppm is hazardous to algae (4) while 5-10 mg/l can cause a 50 percent inhibition of bottom kelp over a four day period (1).

Portmann reports saltwater LC_{50} values of 10-100 ppm for shrimp, 10-33 ppm for pogge and plaice, and greater than 100 ppm for cockles (2). Phenols in general have a toxic threshold to fish in saltwater of 5 ppm (41).

END

Cresol is toxic via all routes of administration. The lethal dose to frogs with subcutaneous administration is 250 mg/kg (22). The reported LD_{50} values for rats are 2,020, 1,800 and 1,350 mg/kg for the meta, para and ortho isomers respectively (7). A dose of 8 grams to man can be fatal. Drinking water is restricted to .001 ppm phenols (1). This however is predicated on taste considerations after probable chlorination. Because cresol can be absorbed through the skin, water for body contact should not contain more than 10 ppm phenol (40). Salt water for swimming should have less than 1 ppm phenols (41).

Other aquatic concentrations of interest include an odor threshold range of .061-4.1 ppm (30) and a lower taste threshold after chlorination of .0001 (1). Waterfowl can be harmed by water containing more than 25 ppm cresol (41). Fish flesh can pick up flavors from exposure to 10 ppm (42).

NAME Cresol

PRODUCTION QUANTITY 81.2 million lbs 1970 (198)

SYNONYMS Methylphenol

COMMON SHIP OR CONTAINER SIZES Tank cars, tank trucks, drums, barrels, carboys, cans, bottles

USCG Grade D or E combustible liquid depending upon flash point

M.P. 11.0 °C

B.P. 202. °C

Sp.G. 1.048

SOLUBILITY 23,500 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD$_5$ = 38% Theo. using acclimated activated sludge-(13)
BOD$_{24}$ = 11.7% Theo. using phenol acclimated pure bacteria culture-(5)
BOD$_5$ = 1.7 lb/lb using sewage seed-(11)
BOD$_8$ = 35.4% Theo. using aniline acclimated activated sludge at a treatment plant-(5)
COD = 2.4 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
Meta					
6.5	24	Salmonide Embryo	TLm		1
21	24	Tench & Bleak	TLm		1
24.5	24	Carp	TLm		1
20	.6	Minnow	Immobilized	15°C	1
19	.5	Perch	Immobilized	15°C	1
10	96	Bluegill	TLm	Distilled	89
24	48	Mosquito Fish	TLm	Pond	48
Ortho					
2.3	24	Salmonide Embryos	TLm		1
11.2	96	Fingerling Catfish	TLm	21°C	1

ppm	hrs	species	param	cond	ref
15.4	24	Tench	TLM		1
24	48	Minnow	Tlm		1
29.5	24	Carp	Tlm		1
55	1	Sunfish	Killed		1
60		Minnow	Killed	17°C	1
66.8	72	Fingerling Catfish	Tlm	21°C	1
70	3	Roach	Killed	21°C	1
110	5	Roach	Killed	9.5°C	1
10	1	Perch	Lethal		15
10	96	Bluegill	Tlm	Distilled	89
24	48	Mosquito Fish	Tlm	Pond	48
13	96	Fathead Minnow	Tlm	Const. Temp.	37
24	96	Bluegill	Tlm	Const. Temp.	37
31	96	Goldfish	Tlm	Const. Temp.	37
39	96	Guppy	Tlm	Const. Temp.	37

Para

ppm	hrs	species	param	cond	ref
4	24	Salmonide Embryo	Tlm		1
5		Trout	Killed	17°C	1
10	1	Perch	Killed		1
13.4	24	Bleak, Tench	Tlm		1
20		Minnow	Killed	17°C	1
21.3	24	Carp	Tlm		1
60	1	Sunfish	Killed		1
100	.5	Minnow	Killed		1
10	96	Bluegill	Tlm	Distilled	89
24	48	Mosquito Fish	Tlm	Pond	48
6.5		Fish	Lethal		80

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
10-100	48	Shrimp	LC50	Aerated	2
>100	48	Cockle	LC50	Aerated	2
10-33	48	Pogge	LC50	Aerated	2
10-33	48	Plaice	LC50	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	2020	Oral	1 (meta)
Frog	250	Lethal Subcutaneous	23
Rat	1350	Oral	1 (ortho)
Rat	1800	Oral	1 (para)

CYANIDES

Cyanides are used in a wide variety of industrial applications ranging from pesticidal control to metal finishing. Typical compounds include hydrocyanic acid, sodium, potassium, and calcium cyanide; and the heavy metal cyanides. Bulk liquid shipments, especially those of hydrocyanic acid, pose a major transportation spill threat.

Most cyanides are freely soluble in water. When spilled, they will rapidly disperse with the formation both of free cyanide anions which is in equilibrium with the undissociated hydrogen cyanide gas. Hydrogen cyanide is a very weak acid and hence remains undissociated at lower pH levels. In general, at pH 7 or lower, less than one percent is dissociated while at pH 9 only 49 percent is dissociated (1). With heat, the undissociated acid can be volatilized. Hydrocyanic acid may interfere with natural biological action in receiving waters. As little as 4 ppm inhibits sewage digestion. Chlorination degrades cyanide to less toxic cyanates. Biodegradation of cyanides is little affected by temperature between 10 and 35 ^{o}C, but at higher or lower levels rates are markedly depressed (1).

Because of the predominance of undissociated hydrogen cyanide under neutral or acid conditions, it is clear that toxicities expressed as cyanide ion actually refer to the acid. Investigations confirm that toxicity is in fact due to the formation of the undissociated species (1).

Cyanides have been reported as toxic to fish in the range 0.05-10 ppm (1). The MLD values for rainbow trout, adult chub, and carp have been reported as .1-.3 ppm, 0.5 ppm, and 10 ppm, respectively (1). Fish food organisms are similarly sensitive, with *Daphnia magna* succombing in 48 hours to 3.4 mg/l. The algae chlorella does not undergo photosynthetic inhibition until cyanide levels reach ≥ 300 mg/l.

Saltwater species vary in 48 hour LC50 values for hydrogen cyanide from .25 ppm for prawn to ≥ 25 ppm for cockles (2). The 24 hour TLm for pin perch is 0.69 ppm as cyanide (1). In general, fresh and saltwater fish display toxic reactions above a threshold of .02 ppm (41). Toxicity increase with acidity, temperature, low oxygen tensions, and zinc and cadmium content (1).

Cyanides are highly toxic via all routes of administration. The oral LD50 value for mice fed hydrogen cyanide is 4 mg/kg body weight (229). The average lethal dose to humans is 50-60 mg with 101 mg being fatal in 15 minutes (56). Acute toxic doses for various livestock range from 40-100 mg for smaller species to 300-920 mg for cattle (1). The median lethal oral dose for sheep fed sodium cyanide has been reported to be 4.15 mg/kg (1). Water for human consumption should not contain more than .01 ppm cyanide (40), while that for livestock should be restricted to .02 ppm cyanide (40). Hydrogen cyanide can be absorbed through skin at toxic levels. Water for body contact should not exceed .02 ppm cyanides (40).

Cyanides have been associated with chromosome breaks in vicia faba (19). Concentrations greater than 5×10^{-3} M are lethal to soil ameoba (8).

The lower taste threshold for hydrocyanic acid is reported to be .001 ppm (4).

Cyanides have been designated toxic substances under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

BARIUM CYANIDE

USCG - POISON B, POISON LABEL

IATA - POISON B, POISON LABEL

SOLUBILITY - 800,000 mg/l at 14 °C

PERSISTENCE

Crystals slowly decompose in air. Barium will rapidly precipitate as sulfate or carbonate. Cyanide will slowly convert to the less toxic cyanate. The cyanide ion is in equilibrium with HCN, a very weak acid.

TOXICOLOGICAL

FRESHWATER TOXICITY

.05/120/Trout/100% killed/ /1
.17/ /Fish/MLD/ /1
.18-.19/96/Sunfish/TLM/Hard & Soft/1
.19/24/Sunfish/TLM/Soft/1
.2/.2/Trout/MLD/ /1
.2/ /Fish/Killed/ /1
.35/2.5/Chub/Killed/ /1
.5/2.65/Adult Chub/MLD/ /1
1.0/.6/Trout/100% Killed/ /1
10.0/1.5/Carp/MLD/ /1

CALCIUM CYANIDE

Calcium cyanide is used to stabilize cement, produce stainless steel, and disinfect soils is generally shipped in boxes, cans, and drums with a maximum capacity of 225 pounds.

Calcium cyanide is soluble in water and decomposes with the gradual liberation of hydrogen cyanide and calcium hydroxide. The hydrogen cyanide gas continues to be formed but is likely to remain in solution. Subsequent dilution and neutralization will sponsor additional discharges of hydrogen cyanide until no calcium cyanide remains. Dissolved cyanide is subject to oxidation to the less toxic cyanate form. This is a very slow process, however, under normal conditions.

The aquatic toxicity of calcium cyanide will be that of hydrogen cyanide and high pH. Cyanide is harmful to fish in the .5-10 ppm concentration range (1). In general, the threshold concentration for fresh and saltwater fish to cyanide is .02 ppm (41). Aquatic plants can be damaged by .025 ppm cyanide (1). The toxicity of cyanides is affected by pH, temperature, dissolved oxygen content, and the presence of minerals. Portman reports LC50's of .55-725 ppm for prawns, cockles, and crabs exposed to potassium cyanide (9).

The median lethal oral dose of calcium cyanide for rats is 39 mg/kg body weight (77). Cyanide, in general, is toxic via all routes including skin absorption. Humans are reported to withstand 18 mg/day of cyanide without harm (1), but drinking water limits are set at .01 ppm per 100 pounds of body weight (40). Water for body contact should not contain more than .02 ppm per 100 pounds of body weight (40). Similarly, livestock should not be given water with more than .02 ppm per 100 pounds of body weight (40).

CALCIUM CYANIDE

USCG - POISON LABEL

IATA - POISON LABEL

PERSISTENCE -

Chemical hydrolysis, etc. - decomposes to $Ca(OH)_2$ + HCN until alkalinity is high enough to stabilize $Ca(CN)_2$. Natural neutralization continues decomposition.

TOXICOLOGICAL

FRESHWATER TOXICITY

.05/130/Brook Trout/100% kill/(CN)/1
.05/ /Fish/MLD/(CN)/1
.1/34/Rainbow Trout/MLD/(CN)/1
.2/.2/Rainbow Trout/MLD/(CN)/1
.35/2.5/Chub/Killed/(CN)/1
.5/2.5/Chub/MLD/(CN)/1
1.07/.3/Trout/100% killed/(CN)/1
10/1.5/Carp/MLD/(CN)/1
.12/96/Sunfish/TLM/hard & soft/1
(60)
.05/2
25/48/Cockle/LC50/as KCN/2
5/48/Crab/LC50/as KCN/2

MAMMALIAN TOXICITY

Species	mg/kg B.W.	Administration Route	Ref.
Rat	50	Oral - Approximate Lethal Dose$_{50}$	77

HYDROGEN CYANIDE

Hydrogen cyanide is employed as an insecticide and chemical intermediate. The 281 million pounds produced in 1971 were shipped in steel gas cylinders, boxed cars as an absorbed gas on inerts, and tank cars.

Hydrocyanic acid is highly flammable. It is freely soluble in water as a gas, and miscible as a liquid. When spilled, the gas may lack sufficient contact with water to cause high dissolved concentrations unless leaking vessels are submerged. Spills of solutions, on the other hand, will cause rapid dispersion of the contaminant through the water column. Hydrogen cyanide is a very weak acid and remains undissociated at ambient pH levels. At pH 7 or lower, less than one percent is dissociated at pH 8, 6.7 percent and at pH 9 only 42 percent is dissociated (1). With heat, the undissociated acid can be volatilized. Hydrocyanic adic may interfere with natural biological action in receiving waters. As little as 4 ppm inhibits sewage digestion. Chlorination degrades cyanide to less toxic cyanates. It is generally recognized that undissociated HCN is more toxic toward aquatic life than the cyanide ion.

Hydrogen cyanide is toxic to most aquatic animal life. The 24 hour TLm for rainbow trout has been reported as .07 ppm (158) while the 96 hour value for bluegill is .18 ppm (158). Most fish are affected in the range .05-.42 ppm (1). Fish food organisms are killed in the same concentration range. Saltwater species vary in 48 hour LC50 values from .25 ppm for prawn to 25 ppm for cockles (9). The 24 hour TLm for pin perch is .069 ppm as cyanide (1). In general, fresh and saltwater fish display toxic reactions above a threshold of .02 ppm (41).

Hydrogen cyanide is highly toxic via all routes of administration. The oral LD50 value for mice is 4 mg/kg body weight (220). The average lethal dose to humans is 50-60 mg with 181 mg being fatal in 15 minutes (58). Acute toxic doses for various livestock range from 40-100 mg for smaller species to 390-920 mg for cattle (1). Water for human consumption should not contain more than .01 ppm cyanide (40), while that for livestock should be restricted to .02 ppm cyanide (40). Hydrogen cyanide can be absorbed through skin at toxic levels. Water for body contact should not exceed .02 ppm cyanides (40).

Cyanides have been associated with chromosome breaks in *Vicia faba* (19). Concentrations greater than 5×10^{-3} M are lethal to soil amoeba (8).

The lower taste threshold for hydrocyanic acid is reported to be .001 ppm (4).

HYDROGEN CYANIDE
PRODUCTION QUANTITY - 231 million pounds - 1971
SYNONYMS - Hydrocyanic Acid, Formonitrile, HCN

COMMON SHIP OR CONTAINER SIZE - Steel cylinders, absorbed on inerts in cans, and in tank cars

DOT (gas) Class A poison, poison gas label, not accepted in outside containers

(sol) Class B poison, poison label, 25 pound in an outside container, unstabilized not accepted

USCG (gas) Poison A, poison gas label

(sol) Poison B, poison gas label - unstabilized not accepted

M.P. = -14 °C

B.P. = 26 °C

Sp.G. = 0.6884

$K_a = 4.93 \times 10^{-10}$, $pK_a = 9.31$

SOLUBILITY - Freely soluble-liquid is miscible

TOXICOLOGICAL

__Fresh Water Toxicity__

ppm	hrs	species	parm	cond	ref
.01		Fish	Lethal		60
.16	72	Young Bass	TLm		227
.07	24	Rainbow Trout	TLm		150
.16	72	Bluegill	TLm	pH 7.6-7.9	161
.165	72	Bluegill	60% Survival	pH 7.6-7.9	161
.08	24	Sunfish	Lethal	pH 7.5-8.98	1
.01-.08	24	Bluegill	Lethal	pH 7.5-8.98	1
.08	24	Large-Mouth Bass	Lethal	pH 7.5-8.98	1
.05-.07	24	Perfosia Annularis	Lethal	pH 7.5-8.98	1
.16	96	Bluegill	TLm	Acclimated	10
.432	96	Physa Heterostrapha	TLm		130
.18	96	Bluegill	TLm		130
.48	90	Guppy	TLm		268
.32	90	Guppy	TLm		268
.56	48	Guppy	TLm		268

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
.080	96	Pin Perch	TLm	as CN	[illegible]
.25	48	Prawn	LC50	as HCN	[illegible]
>25	48	Cockle	LC50	as HCN	[illegible]
>5	48	Crab	LC50	as HCN	[illegible]

Mammalian

species	mg/kg B.W.	administration route	ref
Mice	4		[illegible]

POTASSIUM CYANIDE

Potassium cyanide is used in mining, electroplating, steel manufacturing, fumigating, and orchard operations. World production was estimated at 9,000 tons in 1963. Shipment is primarily in tightly closed or sealed glass or metal containers, hermetically sealed metal lined boxes, steel drums, and fiber containers. Limited bulk shipment of solutions has also been reported.

Potassium cyanide is readily soluble in water, forming cyanide ions which would be in equilibrium with HCN, a very weak acid (see HCN for more information). At room temperature, an aqueous solution of KCN is slowly converted to ammonia and potassium formate. The solution is strongly basic. Cyanide can be oxidized to the less toxic cyanate form with oxidizing agents and high alkalinity. Oxidation from residual oxygen will be slow. Biochemical oxidation will be a more rapid process once acclimation is achieved. The acclimating process, however, will be slow in a spill situation. As little as 15 ppm potassium cyanide can inhibit the oxygen utilization of synthetic sewage 50 percent in 5 days (1).

Potassium cyanide is extremely toxic to fish. Brook trout have been affected by as little as .008 ppm, and killed by .09 ppm in 48 hours (1). Lethal concentrations for other fish under varying circumstances range as high as 5 ppm (1). Potassium cyanide is not quite as severely toxic to other aquatic life forms. Median threshold levels for fish food organisms in the range .04-0.18 ppm (1). The critical range for animal plankton is reported as 40-200 ppm (1). In general, fresh and saltwaters should not contain more than .02 ppm cyanide for the propagation of fish (41). Toxicity is affected by temperature, dissolved oxygen, and solution pH.

Saltwater species are also quite sensitive to potassium cyanide. Zebrafish exhibit a 48 hour TLm of 0.49 while that for their eggs is 117 ppm (138). Portman found LC50 values of .55, >55, and >75 for prawns, cockles, and crabs, respectively.

Potassium cyanide, because of the hydrolysis production of hydrogen cyanide, is highly toxic via all routes of administration. The oral LD50 for dogs has been reported as 1.6 (8) and 5.3 (55) mg/kg body weight. The minimum lethal dose for rats is 10-15 mg/kg (55). Drinking water should not contain more than .01 ppm cyanide (40). Water for livestock should have less than .02 ppm cyanide (40). Hydrogen cyanide can be absorbed through the skin at toxic levels. Cyanide should be limited to .02 ppm or less in water for body contact uses (40). Potassium has caused chromosome breaks in vicia faba (19).

POTASSIUM CYANIDE

USCG - Poison B, poison label

IATA - Poison B, poison label

M.P. - 64°C

Sp.G. - 1.52 at 16°C

SOLUBILITY - 500,000 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

.016/ /Bivalve Larvae/Lethal/ /1
1.00/48/Pulmonate Snail/[illegible]/1
05/Daphnia/Killed/1
0.16/96/Scenedesmus/TLm/1
0.8/48/Daphnia/TLm/ /1
0.6/96/E. Coli/TLm/ /1
0.04/48/Microregma/TLm/ /1
0.16/48/Bluegill/TLm/Temp Con. Aerated/130
0.49/96/Bluegill/TLm/Con. Env./107
0.7/72/Daphnia/TLm/Temp Con./60
0.009/ /Brook Trout/Reduced ability to swim/ /1
0.09/48/Brook Trout/TLm/ /1
0.1/ /Marine fish/irritating/ /1
0.1-0.3/48/Goldfish/Lethal in hard water/ /1
0.18/96/Bluegill Sunfish/TLm, with Low DO/ /1
0.14/1/Trout/Helpless at 5 deg C/ /1
0.175/72/Rainbow trout/Succumbs/ /1
0.20/96/Blacknose Dace/TLm/ /1
0.25-0.30/8/Minnows/Lethal in hard water/ /1
0.25-1.0/ /Fish/Lethal in unaerated water/ /1
0.27/8/Trout/Overturned/ /1
0.40-0.67/96/Bluegill/TLm, Normal DO/ /1
0.5-1.0/8/Minnows/Lethal in distilled water/ /1
0.7/96&48/Bluegill Sunfish/TLm/ /1
0.75/91-110/Goldfish/Lethal/Hot/1
5.0/1/Trout, Sunfish/Lethal in lake water/ /1
5.0/9/Sea Lamprey/Lethal in lake water/ /1
15.0/ /Tadpoles/Lethal/ /1
1.8/24, 48, & 96/Mosquito fish/TLm/Turbid/1

Salt Water Toxicity

0.49/48/Zebrafish adults/TLm/Tem Con Aerated/130
1.17/48/Zebrafish eggs/TLm/Temp Con Aerated/130
.09/48/Prawn/LC50/Aerated/8
05/48/Cockle/LC50/Aerated/8
5/48/Crab/LC50/Aerated/8

Mammalian Toxicity

species	mg/kg B.W.	administration route	ref
Dog	1.6	"	8
Rat	10	"	8
Rat	0.5	Intravenous-MLD	8
Rat	10	Oral-LD50	98
Rat	17	Subcutaneous-LD_{LO}	98
Dog	5.3	Oral	58

SODIUM CYANIDE

Sodium cyanide is employed in mining, orchard operations, electroplating, and steel manufacture. The 155 million pounds produced in 1959 (109) were shipped in tightly closed or sealed bottles or metal containers, wooden boxes with sealed inside metal containers or hermetically sealed metal linings, steel drums, and filter containers.

Sodium cyanide is freely soluble in water forming cyanide ions which would be in equilibrium with HCN, a very weak acid (see HCN for more information). Cyanide can be oxidized to the less toxic cyanate form with oxidizing agents and high alkalinity, but oxidation from residual oxygen will be slow. Biochemical oxidation is a more rapid process once acclimation is achieved. The acclimating process, however, is slow in a spill situation. As little as 1.6 ppm sodium cyanide can inhibit the oxygen utilization of synthetic sewage 50 percent in five days (1).

Sodium cyanide is extremely toxic to fish. Trout have been killed by as little as .05 ppm in 96 hours (109). Lethal concentrations for other fish under varying circumstances range as high as 10 ppm (1). A concentration of 5 ppm is sufficient to make sea lamprey ill (1). Sodium cyanide is not quite as severely toxic to other aquatic life forms. The median threshold level for Polycelis nigra is reported to be 30 ppm (1). The critical range fro Daphnia magna is reported as less than 3.4 ppm (1). In general, fresh and saltwaters should not contain more than .03 ppm cyanide for the propagation of fish (41). Toxicity is affected by temperature, dissolved oxygen, and solution pH.

Saltwater species are also quite sensitive to sodium cyanide. Portman found LC50 values of .25, >25, and >5 for prawns, cockles, and crabs, respectively (9).

Sodium cyanide, because of the hydrolysis production of hydrogen cyanide, is highly toxic via all routes of administration. The oral median toxic dose for sheep has been reported as 4.15 mg/kg body weight (1). The fatal dose for man is reported to be about 0.2 gm, but since the fatal dose for HCN has been given as 50-60 mg, the former may be high (1). Drinking water should not contain more than .01 ppm cyanide (40). Water for livestock should have less than .02 ppm cyanide (40). Hydrogen cyanide can be absorbed through the skin at toxic levels. Cyanide should be limited to .02 ppm or less in water for body contact uses (40).

NAME - Sodium Cyanide

PRODUCTION QUANTITY - 153 million pounds 1959 (105)

SYNONYMS - Cyanogran

COMMON SHIP OR CONTAINER SIZE - Bottles, cans, hermetically sealed containers, steel drums, fiber containers

DOT - (liquid) Class B poison, poison label, 55 gal outside container
(solid) Class B poison, poison label, 200 lb outside container

M.P. - 563 °C

B.P. - 1496 °C

SOLUBILITY - Freely

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
.23	96	Fathead Minnows	TLm		100
.16	96	Bluegill	TLm		100
.25	24	Fathead Minnows	TLm	Soft	100
.24	48	Fathead Minnows	TLm	Soft	100
<3.4		Daphnia Magna	Immobilized	25 °C	1
30		Polycelis Nigra	Threshold		1
0.5	124	Trout	100% Mortality		1
0.28	96	Bluegills	TLm	Soft	1
0.33-0.35	2.5	Minnows	Lethal		1
0.4	1	Minnows	Stopped Eating		1
0.43	96	Fathead Minnows	TLm		1
0.44	48	Fathead Minnows	TLm		1
0.5	4-6	Goldfish & Green Sunfish	Lethal		1
0.5-0.7	21	Minnows	95% Mortality		1
0.60	96	Fathead Minnows	TLm		1
0.75	24	Minnows	50% Mortality		1
0.8	24	Minnows	100% Mortality		1
1.0	0.7-10	Mixed Fish	Lethal		1
1	.5	Trout	100% Mortality		1
1.5	0.8-24	Goldfish & Green Sunfish	Lethal		1
2	1	Trout	Lethal		1
2.0		Sticklebacks	Lethal		1
3.1	1.5	Fish	Depressed Respiration		1
4.3		Hardy Carp	Paralyzed		1
5	.9	Shiner	Killed		1
5	2	Trout, Bluegill	Killed		1
10	.05	Shiner	Killed		1
0.02		Trout Fingerlings	No Effect		1
0.08		Trout	Non-toxic		1
0.1	24	Minnows	No Effect		1
2.3	2.5	Fish	Survived		1
5.0	2	Sea Lamprey	Ill, but Survived		1

Salt Water Toxicity

.95	48	Prawn	LC50	as HCN	2
>95	48	Cockle	LC50	as HCN	2
75	48	Crab	LC50	as HCN	2

Mammalian

species	mg/kg B. W.	administration route	ref
Sheep	4.15	Median Toxic Dose-Oral	1
Sheep	5.99	Oral-Lethal	1

ZINC CYANIDE

USCG - Poison B, Poison Label

IATA - Poison B, Poison Label, 12 kg passenger, no limit cargo

M.P. - Decomposes at 800°C

Sp. G. - 1.852

SOLUBILITY - 5 ppm at 20°C

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates to limited extent. Zinc may precipitate as hydroxide. Cyanide will slowly oxidize to less toxic cyanate form.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for cyanide ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	100	Intraperitoneal-LD_{LOW}	96

CYANOGEN CHLORIDE

Cyanogen chloride is used in warfare agents and insecticides. It is shipped in pressurized cylinders

Cyanogen chloride has a limited solubility in water of 2500 ppm. As a gas, however, little is expected to enter the water unless the low hanging plume is shifted over the surface of the water or leaking cylinders are dropped into the water. The dissolved portion will undergo a slow hydrolysis with the potential release of hydrogen cyanide.

Fish are reported to die at concentrations as low as .08 ppm cyanogen chloride (1). If cyanide is released, the threshold concentration for fresh and saltwater fish will be .02 ppm CN-(41).

Cyanogen chloride is highly toxic via all routes. The oral LD_{50} for rats is reported as approximately 39 mg/kg(85) while subcutaneous administration leads to a value of 26 mg/kg (8). A dose of 50-60 mg of the parent compound cyanogen can be fatal to man.

NAME Cyanogen Chloride

SYNONYMS Chlorine Cyanide

DOT Cyanogen Chloride Containing less than 0.9% H_2O, Poison A,
Poison Gas Label, not accepted in outside container

USCG Poison A, poison gas label

M.P. -6.0 °C

B.P. 13.8 °C

Sp.G. 1.186 as liquid - normally a gas

SOLUBILITY 2500 at 25°C

PERSISTENCE

Chemical Hydrolysis, etc.

Can slowly hydrolyze to release HCN

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	perm	cond	ref
.08		Fish	Killed		1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	20	Subcutaneous	8
Rat	Ca. 30	Oral	8b
Mouse	39	Subcutaneous - Low Lethal Dose	98

CYCLOHEXANE

Cyclohexane is used as a solvent and building block for producing adipic acid, benzene, resins, and paint remover. The 1,730,000,000 lbs produced in 1971 (190) were shipped in glass bottles, metal barrels and drums, tank cars, and tank trucks.

Cyclohexane is a light insoluble liquid which will form a colorless slick on the surface of water when spilled. Cyclohexane is relatively stable, and is not likely to undergo any major transformation after spillage. Intense sunlight will lead to accelerated volatilization. The small amount which dissolves is potentially biodegradable. So little is soluble, however, that no oxygen deficiencies will occur.

Cyclohexane is slightly more toxic than benzene. Threshold limit values of 30-40 ppm have been reported for 96 hrs exposure to various fishes (37). Wallen et al. report a much higher figure, 15,000 ppm in water, for highly turbid water.(1) It would appear that some interaction occurs when suspended solids are prevalent. Equilibrium solubility is generally considered toxic to fish.

Cyclohexane is only moderately toxic to mammals. The range of oral LD_{50} values is 3500-8000 mg/kg body weight (15).

One observer reports a level as high as 20,020 mg/kg for rats (1). It is recommended that no more than 10.5 mg/kg be consumed by humans (63). The chronic threshold dose for rats is .005 mg/kg body weight or .1 mg/l drinking water (15). The presence of .1 percent benzene requires use of benzene toxicological data. The slick formed poses a major hazard to waterfowl and marine mammals.

NAME Cyclohexane

PRODUCTION QUANTITY 1,730,000,000 lbs 1971 (199)

SYNONYMS Hexahydrobenzene, Hexamethylene, Hexanaphthene

LOWEST SHIP OR CONTAINER SIZE Glass bottles, metal barrels & drums,
tank cars, tank trucks

M.P. 6.5 °C

B.P. 81.0 °C

Sp.G. 0.779

SOLUBILITY 55 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
15,500	24,48&96	Mosquito Fish	TLm	Turbid 21°C	1
30	96	Fathead Minnow	TLm	Const. Temp.	37
31	96	Bluegill	TLm	Const. Temp.	37
31	96	Goldfish	TLm	Const. Temp.	37
48	96	Guppy	TLm	Const. Temp.	37

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	29,820	Oral	1
Mammals	5500-6000	Oral	15
Young Rats	8000	Oral	61

2,4-D ACID, ESTERS, SALTS, AND AMINES

The chemical 2,4-D and its derivatives are widely used phenoxyacetic acid based herbicides employed to control many forms of broadleaf plants. The 45 million lbs produced in 1971 (327) were applied as granules, liquid, or an emulsion concentrate on cereal grains, corn, lawns, pastures, and aquatic weeds.

2,4-D acid is soluble to only 620 ppm. The amine is readily soluble and the sodium salt is soluble to 35,000 ppm. When spilled the acid will sink and dissolve slowly while derivatives are more likely to disperse quickly. 2,4-D degrades rapidly in water. A concentration of 1000 ppm was noted to drop to 10 ppb 30 days after application. Some of the removed herbicide was later found absorbed on bottom sediments. In a second application to water, only 1-2 percent of the original 600-967 ppb remained after 31 days. The most rapid decline occurred four days after application. A level of 10 ppm has been noted to persist in pond water for six weeks (22). In soil, various researchers report .4 lb/acre persisted for 4-10 weeks, .5-3 lb/acre persisted 1-4 weeks in moist loam, and standard doses remained approximately one month (72). 2,4-D may interfere with normal biological processes in water. A concentration of 2 mg/l can inhibit growth in aerobic bacteria but does not affect anaerobic or facultative organisms (1). Other work indicates no effect on ammonifying bacteria in soil when applied at 0.25 percent and below. A dosage of 50 ppm can inhibit nitrification completely (22).

The toxicity of 2,4-D and its derivatives depends largely upon the form in which they are applied. The 48 hr TLm for the acid have been reported as 1.1 ppm and 0.9 ppm for rainbow trout and bluegill respectively (354). Similar values for Stonefly and Daphnia pulex are 1.8 ppm and 3.2 ppm (354). Many salts and esters are as toxic to aquatic species. The sodium salt; alkanolamine, ethanol, and isopropanol series; ethylhexyl ester; and amine forms are generally less toxic. In the main, 2,4-D poses a hazard when present above .1 ppm where it is lethal to crustaceans (1). Fish living in waters containing 2,4-D have become unpalatable due to phenolic tastes in their flesh (1).

Aquatic life may concentrate 2,4-D. Eastern oysters have accumulated the butoxy-ethanol ester from 0.1 ppm in water to 18 ppm in themselves over a seven day period. When placed in clean water, however, the oysters purged themselves (22). Sunfish have concentrated 150 ppb in their flesh from water with 1 ppb (22). The concentration is readily reversible once surrounding waters are free of the herbicide.

2,4-D is not considered especially toxic to man. The lethal dose for a 90 kg man is 63 gms (1). Drinking water should be limited to 0.1 ppm (337). This, however, is based on taste threshold levels rather than chronic toxicity. The oral LD50 values for rats, mice, dogs, and mule deer have been determined as 500, 375, 100 (1) and 600 mg/kg body weight (168) respectively. In chronic studies, .20 mg/kg/day was toxic to dogs (1). While tests for carcinogenesis have been negative, root studies with plants show effects on nucleic acid synthesis and c-mitosis (329). Tests with mice have also shown teratogenic eye anomalies (329).

2,4-D is employed because of its phytotoxic activity. Grape plants appear particularly sensitive. As little as 11 mg/l in irrigation water has injured flame tokay and concord grapes (1). When contacted on young leaves, grapes may suffer from as little as .0001 ug. Other broadleaf species show varying sensitivity. Some plants appear to be stimulated by small amounts of the herbicide (22).

NAME 2,4-D Acid, Esters, and Amines

PRODUCTION QUANTITY 45 million lbs - 1971 (327)

SYNONYMS 2,4 (Dichlorophenoxy) Acetic Acid Esters and Amines

M.P. 138 °C

B.P. 160 °C

SOLUBILITY Acid - 620 mg/l at 25 °C
Sodium Salt - 35,000 ppm
Amines - Soluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
Acid					
8 lb/acre		Alligator Weed	Partially Toxic	Miss. River	348
2	72	Nitzschia Palea	Toxic		33
3-4.4	24	Rainbow Trout	TLm	Adjuvants	349
2.2-3.3	48	Rainbow Trout	TLm	Adjuvants	349
43.6 lb/acre		Spatterdock	95 Control		350
1.5-2.5		Bushy Pondweed	Control	Florida Lakes	351
8	48	Bluegill	TLm	With Emulsifier	352
>100		Daphnia Magna	IC50		353
1.1	48	Rainbow Trout	TLm		354
0.9	48	Bluegill	TLm		354
1.6	48	Pteronarcys Californica	TLm		354
3.2	48	Daphnia Pulex	TLm		354
4.9	48	Simocephalus Serrulatus	TLm		354
5	24	Bluegill Eggs	Lethal		355
.015	96	(Naiads) Pteronarcys Californica	LC50	15.5°C	164
1800		Minnows	Safe Con.		1
600		Catfish, Sunfish	Safe Con.		1
350	24	Bluegill, Largemouth Bass	TLm		1
1.0	24	3 mo. old Trout	Toxic	57% ...matic Acid, 12.5% 2,4-D Acid, 6% Emulsifiers	1

PPM	HRS	SPECIES	[illegible]	COND	REF
2.2	48	3 mo. old Trout	Toxic	57% Aromatic Oils, 12.5% 2,4-D Acid, 6% Emulsifiers	1
>100	72	Fathead Minnow	No Toxic Effect	50°F, Huron	426

Salts and Esters

PPM	HRS	SPECIES	[illegible]	COND	REF
350	24	Bass, Bluegill	50% Kill	Esters	1
375	48	Bluegills	TLm	Esters	329
175	24	Bluegills	TLm	Esters	329
100		Bream, Bass	Some Kill		1
1	24	Trout	Toxic		1
2.2	48	Trout	Toxic		1
260		Carp	Not Toxic	Sodium Salt	1
1		Fingerling Bluegills	40% Kill	Butyl Ester	1
5		Fingerling Bluegills	100% Kill	Butyl Ester	1
10		Fingerling Bluegills	100% Kill	Isopropyl Ester	1
40		Fingerling Bluegills	100% Kill	Alkanolamine	1
112		Small Trout	Threshold	Sodium Salt	1
5	24	Bluegill	Lethal	Butyl Ester	1
5	24	Trout	Lethal	Butyl Ester	1
5	24	Sea Lamprey	Unaffected	Butyl Ester	1
.1-.4		Crustaceans	25% Kill	Isopropyl Ester	1
.4-2		Insects	25% Kill	Isopropyl Ester	1
2.4-3.3		Snails	25% Kill	Isopropyl Ester	1
10	192	Bluegill	20% Kill		356
4.2 lb/acre		P. Cordata	85% Kill	Field	350
4.2 lb/acre		Spatterdock	3% Kill	Field	350
10	4	Green Sunfish Eggs	Lethal		357
10	5	Smallmouth Bass Eggs	Lethal		355
6	2	Bluegill Eggs	Lethal		358
10	8 Days	Bluegill	Survival	Ethyl Hexyl Ester	22
10	4 Days	Green Sunfish	Lethal	Ethyl Hexyl Ester	22
10	5 Days	Smallmouth [illegible]	Lethal	Ethyl Hexyl Ester	22
1.0	24	[illegible]equin Fish	LC50	Butyl Ester	22
4.0	24	[illegible]egill	LC50	Olate-1, Propylene Diamine	22

ppm	hrs	species	param	cpnd	ref
6.9	24	Bluegill	LC50	Butyl Ester	[illegible]
16	24	Bluegill	LC50	Butyl Ester	[illegible]
250	24	Rainbow Trout	LC50	Butyl Ester	[illegible]
250	24	Rainbow Trout	LC50	Amine	[illegible]
80	24	Lake Emerald Shiner	LC50	Ethylhexyl Ester	[illegible]
620	24	Lake Emerald Shiner	LC50	Ethylhexyl Ester	[illegible]
1160	24	Harlequin Fish	LC50	Sodium Salt	[illegible]
0.8	48	Bluegill	LC50	Isopropyl Ester	[illegible]
0.96	48	Rainbow Trout	LC50	Propylene Glycol Butyl Ether Ester	[illegible]
1.1	48	Rainbow Trout	LC50	Propylene Glycol Butyl Ether Ester	[illegible]
1.3	48	Bluegill	LC50	Butyl Ester	[illegible]
1.4	48	Bluegill	LC50	Mixed Butyl and Isopropyl Ester	[illegible]
2.1	48	Bluegill	LC50	Butoxyethanol Ester	[illegible]
3.7	48	Bluegill	LC50	Butoxyethanol Ester	[illegible]
450-900	24 & 48	Bluegill	LC50	Alkanolamine, Ethanol, and Isopropanol Series	[illegible]
166-542	24 & 48	Bluegill	LC50	Dimethylamine	[illegible]
1.5	24,48	Bluegill	LC50	Di-N,-V-dimethylcocoamine	[illegible]
8.8-60.1	24,48	Bluegill	LC50	Isooctyl Ester	[illegible]
2.1	24,48	Bluegill	LC50	Butoxyethanol Ester	[illegible]
1.4	24,48	Bluegill	LC50	Butyl Ester	[illegible]
1.6	24	Gammarus Lacustris	LC50	Butoxyethanol Ester	[illegible]
2.1	24	Gammarus Lacustris	LC50	Propylene Glycol Butyl Ester	[illegible]
6.8	24	Gammarus	LC50	Isooctyl Ester	[illegible]
0.5	24	Stonefly	LC50	Butyl Ester	[illegible]
56	24	Stonefly	LC50	Butyl Ester	[illegible]
>100	24	Gammarus Lacustris	LC50	Dimethylamine	[illegible]
1000	48	Stonefly	LC50	Butoxyethanol Ester	[illegible]

ppm	hrs	species	test	cmpd	ref
1000	48	Gammarus Lacustris	LC50	Propylene Glycol Butyl Ether Ester	22
3200	48	Daphnia Pulex	LC50	Propylene Glycol Butyl Ether Ester	22
2.0	96	Striped Bass	TLm	Butyl Ester	419

Salt Water Toxicity

ppm	hrs	species	test	cmpd	ref
Acid					
5	48	Killifish	50% Kill		347
3		Brown shrimp	10% Kill	Continuous Flow	23

Various Salts

1-5	96	Oyster	30% Growth Decrease	21
4.5	96	Spot	TLm	22
1	4	Phytoplankton	16-49% Inhibition	23
2	4.0	Brown Shrimp	10% Lethal	23
5	48	Oyster	Ester	411

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	900	Oral-Acid	1
Mice	375	Oral-Acid	1
Dog	100	Oral-Acid	1
Mule Deer	607	Oral-Acid	155
Rat	100	Oral-Acid	98
Chicken (Avian)	300	Oral-Alkanolamine	98
Mice	250	Low Lethal Dose-Intraperitoneal-Amyl Ester	98
Rat	320	Oral-Butyl Ester	98
Rat	520 mg/m^3	Inhal.-Crotyl Ester	98
Mice	512	Intraperitoneal-Low Lethal Dose-Inositol Hexaester	98
Rat	500	Oral-Isopropyl Ester	98
Rat	610	Oral-Sodium Salt	98

Dalapon

Dalapon is a selective herbicide used to control many perenial grasses. The estimated 1971 production was 5 million lbs. The acid is not typically used directly, but formulated in combination with 85 percent sodium salt or a mixture of sodium and magnesium salts.

As a chlorinated carboxylic acid, Dalapon should be moderately resistent to biochemical degradation. Limited data indicates a similar response in soil. When applied at 5-40 lb/acre to moist loam-soil, Dalapon persisted 10-60 days under summertime conditions in a temperate climate. Little or no leaching occured. A concentration of 50 ppm in soil persisted <2 to >8 weeks.[11]

Dalapon is only moderately toxic to aquatic life. The 96 hour LC$_{50}$ value for bluegill has been reported as 105 ppm.[111] For coho salmon and bass, the 48 hour LC$_{50}$ is 340 and 100 ppm respectively.[1] Cattails can be eradicated with application of 20 lb/acre,[111] Pteronarcy sp. nymphs have a 96 hour LC$_{50}$ in excess of 1000 ppm.[111] In saltwater, 1 ppm of Dalapon has been found to kill 30 percent of the brown shrimp in 24 hours and 40 percent in 48 hours. The same dose had no effect on longnose killifish over a 48 hour period.[111]

Dalapon is relatively nontoxic to mammalian life. The oral LD$_{50}$ for rats is 4700 mg/kg body weight.[111]

DALAPON

SYNONYMS - Dichloropropionic Acid, Dowpon, Basfapon, Unipon

PRODUCTION QUANTITY - 5,000,000 lbs - 1971

M.P. 20°C

B.P. 185°C

Sp. G. - 1.389

SOLUBILITY - 450,000 ppm

PERSISTENCE

Oxygen Demand - Moderately degradable.

Chemical Hydrolysis, etc. - Volatile in acid form.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
5000		Shiner	100% Kill		1
390	96	Shiner	LC_{50}	Hard	1
395	96	Shiner	LC_{50}	Soft	1
1000	48	Bass	LC_{50}		1
340	48	Coho	LC_{50}		1
115	24	Bluegill	LC_{50}		110
115	48	Bluegill	LC_{50}		110
105	96	Bluegill	LC_{50}		110
>1000	96	Pteronarcys Sp. (Nymphs)	LC_{50}	60°F	103
20 lb/acre		Cattails	Eradicated	Farm Ponds	105

Saltwater Toxicity

1	24	Brown Shrimp	LC_{30}		110
1	48	Brown Shrimp	LC_{40}		110
1	24	Longnose Killifish	No Effect		110
1	48	Longnose Killifish	No Effect		110

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	4700	Oral	129
Mouse	7100	Oral	129
Rabbit	3860	Oral	140

DDT

DDT has been one of the most publicized pesticides ever produced. It is a polychlorinated aromatic that finds use in many domestic, agricultural, and silvicultural applications. The 45 million lbs produced in 1971 (387) were shipped in fiber drums, bags, bottles, and tins for application in the wettable powder, liquid, and emulsion concentrate forms.

DDT is practically insoluble in water. When shipped in a wettable form, however, spills will result in dispersion through the water column. DDT is considered quite stable. Hydrolysis and photodegradation occur to a very limited extent. Iron salts, especially ferric chloride, will catalyze decomposition. Some DDT in water will transfer to the atmosphere. This is believed to result from codistillation with water and is accelerated by a tendency for DDT to concentrate near the surface. The significance of this phenomenon has not been quantified (22). In soils, DDT has been noted to undergo a 5 percent loss each year (1). When applied to sandy loam, 100 ppm was present at 39 percent after 17 years. Soil residues in a Maine forest showed little decrease from the 1 lb/acre application rate after 9 years. It has been suggested that residues may persist for more than 30 years (22).

DDT is highly toxic to all forms of aquatic life. In fact, most aquatic life is more susceptible to DDT than terrestial forms (1). The 96 hr TL50 values for many common fish varieties fall in the range .002-.016 ppm (380). Invertebrates may be slightly less sensitive. The 48 hr TL50 values for glass shrimp, damselfly, and scud are reported as .0042, .0225, and .0016 ppm, respectively (311). The mode of application is very critical in determining resulting toxicity. In studies with trout, DDT in acetone was not toxic at 30 mg/l, and DDT in fuel oil was not toxic at 20 mg/l; while in xylene it was toxic at 3 mg/l, in emulsion it was toxic at 1 mg/l, and in kerosene it was toxic at 0.3 mg/l (1).

This explains the wide variety of data ranging from the death of common suckers at .001 ppm to a toxic limit of 0.1 ppm for goldfish (1). In salt water, DDT has exhibited a TLm of .0028 ppm to killifish (397) and a 96 hr EC50 of .03 ppm to oysters (23). Blue crabs have been killed in 1972 hrs when exposed to .001 ppm (23).

Fish can accumulate DDT in their livers and intestines. Oysters have been shown to concentrate DDT up to 70,000 times, while the average mollusk accumulation rate is a factor of 1210-9000. Brook trout were found to concentrate 10 times as much DDT from food sources as from surrounding water (400).

DDT can be toxic to man at a dose of 281 mg/kg body weight with fatality in a 70 kg man resulting from 30 gms (1). Ingestion of 1 gm causes tremors and convulsions (1). Drinking water should not contain more than .042 ppm (327). In experimental animals, the oral LD50 has been reported as 250 mg/kg body weight for rats and 150 mg/kg for mice (1). With chronic feeding, dose rates as low as .05 mg/kg in rats have resulted in adverse effects (15). On the other hand, people exposed to 35 mg/day for 18 months showed no toxic systems (1). DDT can produce tastes in water when present at 0.3 ppm (1).

DDT has been implicated as a low level contaminant capable of disturbing reproduction in birds through softening of eggs. Tests for carcinogenesis in mice, rats, and fish have all produced tumors. Mutagenic tests in mice were negative, but with plants, DDT produced C-mitosis and chromosome breaks. Tests for teratogenesis have been negative (329).

DDT is not considered particularly phytotoxic. Some plants, however, such as cucumbers, squash, tomatoes, strawberries, and some peas may be retarded by 25 lbs/acre (1). Residues of 110 ppm in soil were found to give yields reduced by 66 percent in beans, 40 percent in carrots, 91 percent in tomatoes and 33 percent in peas. Turnips showed no effects (22). Phytoplankton exposed to 1 ppm for four hrs showed an activity reduction of 77.2 percent. Significant morphological and physiological changes were noted in phytoplankton after exposure to 0.1 ppb DDT for 3 days (22). Plants can also accumulate DDT.

DDT has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

NAME DDT

PRODUCTION QUANTITY 45 million lbs - 1971

SYNONYMS 1-1-1-Trichloro-2-2-bi(P-chloro-phenyl) Ethane;
Peralato-Spray; Chlorophenothane; Dicophane; Pentachlorin;
Gesarol; Santobane

COMMON SHIP OR CONTAINER SIZE Fiber drums, bags, bottles, tins

M.P. 109 °C

B.P. 110 °C Decomposes

SOLUBILITY .01 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
0.007	24	Salmon	TLm		1
0.01		Dace	100% Kill		1
0.016	96	Bluegill	TLm		1
0.187	96	Goldfish	TLm		1
0.043	96	Guppies	TLm		1
0.032	96	Fathead	TLm		129
0.0186	96	Fathead	TLm		129
5.0		Carp Embryo	50-100% Mortality		136
.009	96	Gammarus Lacustris	TLm	Tech. in Acetone	158
.016	96	Catfish	TL50	Predicted	160
.005	96	Bullhead	TL50	Predicted	160
.021	96	Goldfish	TL50	Predicted	160
.019	96	Minnow	TL50	Predicted	160
.010	96	Carp	TL50	Predicted	160
.005	96	Sunfish	TL50	Predicted	160
.008	96	Bluegill	TL50	Predicted	160
.002	96	Bass	TL50	Predicted	160
.007	96	Rainbow	TL50	Predicted	160
.002	96	Brown	TL50	Predicted	120
.004	96	Coho	TL50	Predicted	160
.008	96	Perch	TL50	Predicted	160
.0089	24	Rainbow	TL50		131
.0072	96	Rainbow	TL50		131
.0242	24	Fathead	TL50		131
.0188	96	Fathead	TL50		131

[illegible]	[illegible]	species	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Goldfish	[illegible]		[illegible]
[illegible]	[illegible]	Goldfish	[illegible]		[illegible]
[illegible]	[illegible]	Bluegill	[illegible]		[illegible]
[illegible]	[illegible]	Bluegill	[illegible]		[illegible]
[illegible]	[illegible]	Bass	[illegible]		[illegible]
[illegible]	[illegible]	Bass	[illegible]		[illegible]
[illegible]	[illegible]	Daphnia Magna	[illegible]		[illegible]
[illegible]	[illegible]	Sand Shrimp	[illegible]		[illegible]
[illegible]	[illegible]	Sowbug	[illegible]		[illegible]
[illegible]	[illegible]	Sowbug	[illegible]		[illegible]
[illegible]	[illegible]	Glass Shrimp	[illegible]		[illegible]
[illegible]	[illegible]	Glass Shrimp	[illegible]		[illegible]
[illegible]	[illegible]	Damselfly	[illegible]		[illegible]
[illegible]	[illegible]	Damselfly	[illegible]		[illegible]
[illegible]	[illegible]	Scud	[illegible]		[illegible]
[illegible]	[illegible]	Scud	[illegible]		[illegible]
.100	96	Acroneuria Pacifica	Tlm		[illegible]
.100	96	Pteronarcys Californica	Tlm		[illegible]
.010	96	Claassenia Sabulosa	Tlm		[illegible]
[illegible]	96	Arctopsyche Grandis	Tlm		[illegible]
.001	[illegible]	Daphnia Magna	Tlm		[illegible]
[illegible]	[illegible]	Fathead	Tlm		[illegible]
[illegible]	[illegible]	Rainbow	[illegible]		[illegible]
[illegible]	[illegible]	Bluegill	[illegible]		[illegible]
.0014	[illegible]	Daphnia Magna	[illegible]		[illegible]
[illegible]	[illegible]	Mosquito Fish	[illegible]		[illegible]
[illegible]	[illegible]	Brook Trout	[illegible]		[illegible]
[illegible]		Salmon	[illegible]		[illegible]
[illegible]	[illegible]	Salmon	[illegible]		[illegible]
[illegible]	[illegible]	Goldfish	[illegible]		[illegible]
[illegible]	[illegible]	Mosquito Fish	[illegible]		[illegible]
[illegible]	[illegible]	Mosquito Fish	[illegible]		[illegible]
.0074	[illegible]	Fathead	[illegible]		[illegible]
[illegible]	[illegible]	Fathead	[illegible]		[illegible]
100	96	Tubificid-Limnodrilus Sp	[illegible]		[illegible]
.021	[illegible]	Coho	Tlm		[illegible]
.015	[illegible]	Coho	Tlm		[illegible]

Salt Water Toxicity

.012	[illegible]	Shrimp Larvae	Tlm		[illegible]
[illegible]	[illegible]	Shrimp Adult	Tlm		[illegible]

ppm	hrs	species	[illegible]	cond	ref
1.0	96	Oyster Larvae	100% Kill		1
.0020	48	Killifish	50% Kill		347
0.1	24	Sheepshead Minnow			330
0.1	48	Sheepshead Minnow	EC50 .008		330
.2 lb/acre	168	Blue Crabs	17% Lethal	Salt Mash Stream	359
.2 lb/acre	168	Marsh Fiddler Crab	75% Lethal	Salt Marsh	359
.2 lb/acre	168	Red Jointed Fiddler Crab	35% Lethal	Salt Marsh	359
.03	96	Oyster	EC50		[illegible]
.001	192	Blue Crab	Lethal		[illegible]

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	250	Oral	1
Mice	150	Oral	1
Chickens	1300	Oral	[illegible]

DIAZINON

Diazinon is a pyrimidinyl phosphorothioate insecticide commonly used around households, and on lawns, vegetables, and fruits. The 10 million lbs produced in 1971 (327) were shipped as dusts, granules, wettable powders, emulsion concentrates, solutions, and pressurized mixtures.

Diazinon is relatively insoluble in water. If spilled in a wettable form, however, it may soon spread through the water column. In field trials at Hanford, Washington 20 gallons of 48 percent diazinon in xylene were spilled over a 20 x 20 foot area. Within 30 minutes, the greatest single concentration level found was 25 ppm total phosphate, 51.4 ppm total organic carbon (401). When applied to soil, diazinon persisted at detectable levels for periods of 9 days to 12 weeks (22). Some of this variation may be due to soil moisture. Diazinon hydrolyzes quite rapidly. It is not likely to persist in water for more than a week or two.

Diazinon is quite toxic to aquatic life. The 48 hr EC50s for rainbow trout and bluegill have been reported as 0.17 ppm and 0.03 ppm, respectively (364). A concentration of 4 ppm caused abnormal behavior in guppies after 4 hours, and death in 24-48 hours (1). Daphnia magna may be immobilized by .0043 ppm over a 50 hour period (300). Other invertebrates are similarly sensitive. While fish may accumulate diazinon by a factor of 10 from water, nearly 50 percent is lost in less than a week (22).

Diazinon can be toxic to man. The estimated fatal dose for a 70 Kg man is 25 gms (1). Drinking water should not contain more than 0.1 ppm (337). In laboratory rats, oral LD50 values of 76-264 mg/Kg body weight have been reported (1,22). Birds appear to be far more sensitive. The LD50 for young mallard ducks is 3.5 mg/Kg body weight, and that for young pheasants is 4.3 mg/Kg (22). Diazinon at 0.5 mg/l has produced chromosome aberrations in human lymphocytes. Tests for teratogenesis yielded congenital malformations in chicks (15).

NAME Diazinon

PRODUCTION QUANTITY 10 million lbs - 1971 (387)

SYNONYMS O,O-Diethyl O-(2-Isopropyl-6-Methyl-4-Pyrimidinyl) Phosphorothioate; G24480; Basudin Spectracide; Dipofene; Diazitol;

B.P. 83°C

Sp.G. 1.116

SOLUBILITY 20°C 40 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	meas	cond	ref
4.0	48	Guppies	100% Kill		1
5.0		Carp Embryo	50-100% Kill		1
0.35	24	Rainbow	LC50		309
0.084	24	Bluegill	LC50		330
0.17	48	Rainbow	LC50		330
0.09	96	Rainbow	LC50		330
0.052	24	Bluegill	LC50		330
0.030	48	Bluegill	LC50		330
0.022	96	Bluegill	LC50		330
0.0043	50	Daphnia Magna	Immobilized		365
.2/lbs Acre	24	Mosquito Fish	100% Kill	Ponds	373
.025	96	Pteronarcys Sp. (Nymphs)	TLm	60°C	303
0.17	48	Rainbow	EC50		354
0.03	48	Bluegill	EC50		354
0.074	48	Pteronarcys Californicus	EC50		354
0.0009	48	Simocephalus Serrulatus	EC50		354
0.025	96	Pteronarcys Cal (Naiads)	LC50	15.5°C	370
0.001		Spot	100% Antienzyme Activity		370
0.001		Longnose Killifish	76% Antienzyme Activity		370
0.4	0.1	Wild Larvae	13% Lethal	Flowing Water	383

Mammalian.

species	mg/kg B. W.	administration route	ref
Rat	[illegible]	Oral	1
Rat	[illegible]	Oral	1
Man	[illegible]	Oral	1

Dicamba

Dicamba or Banvel is a herbicide often used to control brush near rights-of-way, and broadleaf weeds in corn, sorghum, grain, pastures, turf, and non-cropland. Production in 1971 was estimated to be 6 million lbs. The active ingredient is often applied as the dimethylamine salt, as an oil soluble formulation, or in granular form.

Dicamba is a halogenated anisic acid compound likely to resist biochemical degradation. When applied to soil, it was reported to persist for 3 months.[22]

Dicamba is only moderately toxic to aquatic life. The 48 hour Tlm value for bluegill is reported as 40 ppm[511] while that for rainbow trout was 35 ppm.[22] Sanders[511] found the 48 hour Tlm values for six freshwater crustaceans exceeded 100 ppm.

The oral LD_{50} value for rats is reported as 2900 mg/kg body weight.[22]

DICAMBA

SYNONYMS - Banvel, 3,6-Dichloro-o-anisic acid, Banex, Mediben

PRODUCTION QUANTITY - 6,000,000 lbs, 1971

M.P. 114°-116°C

SOLUBILITY - 4500 ppm @ 25°C

PERSISTENCE

Oxygen Demand - Moderately persistent

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
151	24	Juvenile Coho Salmon	LC$_{50}$		22
35	48	Rainbow Trout	Est-LC$_{50}$		22
130	48	Bluegill	Est-LC$_{50}$		22
10	24	Gammarus Lacustris	LC$_{50}$		22
5.8	48	Gammarus Lacustris	LC$_{50}$		22
120	48	Coho Salmon	TLm		188
320		Rainbow Trout	No Effect		188
35	48	Rainbow Trout	LC$_{50}$		20
130	48	Bluegill	LC$_{50}$		20
>100	48	Gammarus Lacustris	TLm		412
>100	48	Palemonetes Kadiakensis	TLm		412
>100	48	Asellus Brevicaudus	TLm		412
>100	48	Orconectes Nais	TLm		412
>100	48	Daphnia Magna	TLm		412
>100	48	Cypridopsis Vidua	TLm		412
40	48	Bluegill	TLm		412

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	2900	Oral	22
Rat	1040	Oral	06

Dichlobenil

Dichlobenil or Casoron is a halogenated organic herbicide employed for weed control in cranberry bogs, nurseries, fruit orchards, alfalfa, and ladino seed fields. It can also be used for aquatic weeds in non-flowing waters. Typical formulations are granular or wettable powders.

Dichlobenil is considered relatively persistent in the open environment. When applied at 4 lb/acre in soil, it persisted for 10 months in one study and was found at 0.12 ppm in cranberry bogs after 2 years in another study. The nitrile does not appear to leach downward into the soil column. Persistence is greater for granular applications than for those as a wettable powder.[11]

Dichlobenil is moderately toxic to aquatic life. The 96 hour LC_{50} for bluegill is reported to be 14.7 ppm.[5,11] In tests with wettable powders and granular herbicide, the 24 hour LC_{50} for bluegill was 17 ppm and 20 ppm.[11] Fish food organisms are slightly more sensitive: the 48 hour LC_{50} for Daphnia pulex is 3.7 ppm while immobilization of Daphnia magna occurs at 9.8 ppm. Sanders[5,11] found 48 hour TLm values for six freshwater crustacea in the 7.8-34 ppm range. Bluegill have been found to concentrate Dichlobenil in their tissues above sublethal ambient levels.

Dichlobenil is not particularly toxic to mammals. The oral LD_{50} for rats is 3160 mg/kg body wieght.[11] Similarly, young mallard ducks and pheasants are reported to display a median lethal dose level of >2000 and 1189 mg/kg body weight respectively.[11]

DICHLOBENIL

SYNONYMS - Casoron 133, 2,6-Dichlorobenzonitrile, 2,6-DBN, Du-Sprex, Nia 5996

M.P. 144-145°C

SOLUBILITY - 18 ppm @ 20°C

PERSISTENCE

Oxygen Demand - Appears quite persistent. Esters have been found to bioconcentrate in sunfish.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Param	Cond.	Ref.
17	24	Bluegill	LC_{50}	Wettable Powder	22
22	24	Bluegill	LC_{50}	Wettable Powder	22
23	24	Rainbow Trout	LC_{50}	Wettable Powder	22
37	24	Bluegill	LC_{50}	Granular	22
120	24	Harlequin Fish	LC_{50}	Granular	22
>20	48	Redear	LC_{50}	Granular	22
20	48	Rainbow Trout	LC_{50}	Granular	22
20	48	Bluegill	LC_{50}	Granular	22
25	192	Green Sunfish, Lake Sucker, Smallmouth Bass	Survived		22
10	192	Bluegill Fry	Survived		22
16	24	Gammarus Lacustris	LC_{50}		22
42	24	Pteronarcys Sp.	LC_{50}		22
42	24	P. Californica	LC_{50}		22
1.5	48	Gammarus Lacustris	LC_{50}		22
3.7	48	Daphnia Pulex	LC_{50}		22
4.4	48	P. Californica	LC_{50}		22
5.8	48	Simocephalus Serrulatus	Immobilization		22
3.7	48	Daphnia Pulex	Immobilization		22
9.8		Daphnia Magna	Immobilization		22
14.7	96	Bluegill	LC_{50}		413
12.5	96	Smallmouth Bass	LC_{50}		413
18.0	48	Gammarus Lacustris	TLm		412

ppm	hrs	Species	Parm	Cond.	Ref.
10.0	96	Gammarus Lacustris	TLm		419
9.0	48	Palaemonetes Kadiakensis	TLm		419
34.0	48	Asellus Brevicaudus	TLm		419
22.0	48	Orconectes Nais	TLm		419
10.0	48	Daphnia Magna	TLm		419
7.0	48	Cypridopsis Vidua	TLm		419
20.0	48	Bluegill	TLm		419

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	3160	Oral	22

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	>2000	Oral	22
Pheasants	1189	Oral	22
Pheasants	1000-3500 ppm	LC_{50}-five days feed	22
Coturnix	>5000 ppm	LC_{50}-five days feed	22

Dichlone

Dichlone or Phygon is a chlorinated naphthoquinone utilized as a fungicide. It is typically applied as a wettable powder or dust for seed treatment and foliage protection.

Dichlone does not retain its toxicity for long after release. It is also susceptible to hydrolysis under alkaline conditions. Consequently, when spilled, it is likely to sink and decompose near the bottom.

There may still be significant risk of damage to aquatic life, however, since dichlone is quite toxic. The 48 hour TLm for bluegill is reported as 0.12 ppm.[1,11] The 96 hour TLm values for trout and catfish are 0.074 and 0.14 ppm respectively.[1] Fish food organisms such as Daphnia magna are immobilized at 0.014 ppm.[1,11]

Dichlone may be irritating to the skin and mucous membranes of sensitive people. It can also depress the central nervous system. The oral LD_{50} to rats is reported to be 1300 mg/kg body weight.[9] For young mallards, the oral LD_{50} is >1000 mg/kg body weight.[11]

DICHLONE

SYNONYMS - Phygon, Phygon XL; 2,3-Dichloro-1,4-naphthoquinone

M.P. 193°C

B.P. 275°C sublimes

SOLUBILITY - .1 ppm @ 25°C

PERSISTENCE

Oxygen Demand - Loses toxicity rapidly

Chemical Hydrolysis, etc. - Hydrolyzes in alkali

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
0.1	0.5	Coho Salmon	No Kill		1
0.5	0.25	Coho Salmon	60% Kill		1
0.5	0.25	Coho Salmon	100% Kill		1
0.07	48	Largemouth Bass	TLm		1
0.074	96	Trout	TLm		1
0.14	96	Catfish	TLm		1
0.04	24	Bluegill	LC_{50}		231
0.014		Daphnia Magna	LC_{50}		253
0.5		Algae	Control	Ponds	308
0.075	24-48	Rainbow	TLm	Well Water	376
0.11-0.15	24-96	S. Salicastica Hydrofiles	TLm	Soft	376
0.165	96	Gammarus Lacustris	TLm	In Acetone	388
0.043	48	Salmon	LC_{50}		80
0.09	48	Rainbow Trout	TLm		409
0.24	48	Gammarus Lacustris	TLm		412
0.10	96	Gammarus Lacustris	TLm		412
0.45	48	Palaemonetes Kadiakensis	TLm		412
0.30	48	Asellus Brevicaudus	TLm		412
3.2	48	Orconectes Nais	TLm		412
0.025	48	Daphnia Magna	TLm		412
0.23	48	Cypridopsis Vidua	TLm		412
0.12	48	Bluegill	TLm		412
0.04	96	Bluegill	LC50		354

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1500	Oral	6
Rat	1300	Oral	22

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	>2000	Oral	22

Dichlorvos

Dichlorvos or DDVP is an organophosphate insecticide. The less than 1 million pounds produced in 1971 were used to control agricultural and household pests. It is typically formulated as an emulsion concentrate, oil-base concentrate, ready-to-use spray, aerosol, and space spray. Dichlorvos is also used in flea collars, baits, and resin strips.

Dichlorvos is only slightly soluble in water. After application, it has been found to persist in water for 69 days at 20°C.[11] If spilled, the heavy liquid is likely to sink to the bottom and become associated with sedimentary matter.

Dichlorvos is quite toxic to aquatic life. The 48 hour LC_{50} for Bluegill is reported as 0.7 ppm.[11] Fish food organisms are even more sensitive. The 48 hour LC_{50} for Daphnia pulex, Gammarus lacustris, and P. californica are 0.00007, 0.001, and 0.010 ppm respectively.[11] Immobilization for the Daphnia pulex occurs at 0.000066 ppm.[11] In saltwater, the 24 hour LC_{50} for sand shrimp, hermit crabs, and grass shrimp are 0.015, 0.140, and 0.300 ppm respectively.[11]

Like most organophosphate pesticides, Dichlorvos is a contact and stomach poison active through cholinesterase inhibition.[9] The oral LD_{50} for rats is 56-80 mg/kg body weight[11] while the dermal value is 107 mg/kg body weight.[111] Young mallards and pheasants have an oral LD_{50} of 7.8 and 11.3 mg/kg body weight respectively.[11]

Sanders[111] found the 48 hour TLm to six freshwater crustacea to be in the range .035-3.2 ppm. In chronic studies, coho salmon have been found to be safe in concentrations up to 0.042 ppm over a 21 day period.[1]

DICHLORVOS

SYNONYMS - DDVF, DDVP, Dichlorphos, 2,2-Dichlorovinyl O,O-dimethyl Phosphate, Dedevap, Divipan, Herkol, Mafu, Marvex, Nogos, No-Pest, Nuvan, OKO, Phosvit, Vapona

PRODUCTION QUANTITY - >1,000,000 lbs - 1971

IATA - Class B poison, poison label

B.P. 140°C @ 20 mm

Sp. G. = 1.44

SOLUBILITY - 10,000 ppm

PERSISTENCE

Oxygen Demand - Persists 62 days in water at 20°C (22)

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
1	24	Bluegill	LC_{50}		22
0.7	48	Bluegill	LC_{50}		22
10	24	Harlequin Fish	LC_{50}		22
6.5	48	Harlequin Fish	LC_{50}		400
0.003	24	Gammarus Lacustris	LC_{50}		27
0.021	24	Pteronarcys Sp.	LC_{50}		22
0.025	24	P. Californica	LC_{50}		22
0.00007	48	Daphnia Pulex	LC_{50}		22
0.001	48	Gammarus Lacustris	LC_{50}		22
0.010	48	P. Californica	LC_{50}		22
.00026	48	Simocephalus Serrulatus	Immobilization		22
.000066	48	Daphnia Pulex	Immobilization		22

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
0.010	24	Sand Shrimp	LC_{50}		22
0.150	24	Hermit Crab	LC_{50}		22
0.300	24	Grass Shrimp	LC_{50}		22

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	56-80	Oral	22
Mice	4	Oral	22
Rat	107	Dermal	414

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	7.0	Oral	22
Young Pheasants	11.3	Oral	22
Mallards	>5000 ppm	LC_{50}, 5 days	22

Dieldrin

Dieldrin is one of the polyhalogenated organic pesticides. The 670,000 lbs produced in 1970 were used for a residual poison against soil insects, cotton pests, household and public health insects. It is typically formulated as a wettable powder, emulsifiable concentrate, dust, granule, fertilizer mixture, seed dressing, or solution.

Dieldrin, soluble to .186 ppm in water, is a heavy solid likely to sink when spilled. It can be affected by strong mineral acids, but is quite persistent under normal conditions. Studies[111] have shown 100 percent remaining in river water after 8 weeks. An application of 1 lb/acre in soil continued to kill aquatic beetles for a period of 10 months.[1] Other studies in soil showed 100 ppm persists more than 4 years, and 25 ppm up to 8 years. One application of 100 ppm in sandy loam soil was analyzed at 31 percent after 15 years.[11] Some inert diluents are believed to catalyze decomposition.

Dieldrin, a decomposition product of endrin, is highly toxic to aquatic life. The 96 hour TLm to bluegill has been reported as 0.01 ppm,[1] 0.0079 ppm,[111] and 0.008 ppm.[111] Toxicity to the bluegill increases with temperature in the range 45-85°F.[111] Other 96 hour LC_{50} data include 0.5 ppm for catfish,[111] 0.19 ppm for guppy,[111] 0.016 ppm for fathead minnow, and 0.013 ppm for rainbow trout.[111] Fish food organisms are also quite sensitive to Dieldrin. A concentration of 0.7 killed half of a population of Gammarus lacustris in 96 hours.[111] Similarly, the 96 hour TLm for mayflies is 0.0005 ppm.[111] Trout can concentrate Dieldrin 3300 fold from water with 0.0023 ppm and algae 150 fold in 7 days when exposed to 1 ppm.[11]

In saltwater, a concentration of 0.05 ppm Dieldrin killed an entire sample of mullet in 5 hours. The 48 hour TLm for brown and white shrimp is 0.025-0.05 ppm.[11] Oysters in flowing seawater have concentrated 0.001 ppm 1000 fold in 10 days.[11]

Dieldrin is a contact and stomach poison which can readily be absorbed through the skin. The toxic action is not quick, but Dieldrin's persistency makes it a chronic residual hazard. The oral LD_{50} for rats is reported as 60-87 mg/kg body weight.[1] Birds can also be affected. The LD_{50} for bobwhite quail chicks and mallard ducklings is 39 and 200 ppm respectively over a 5 day feeding period.[11] Dieldrin can also affect egg fertility and the thickness of egg shells when ingested by parent birds.[11] Laboratory studies show Dieldrin yields a positive carcinogenic response.[11] It can also produce C-mitosis in plant sprouts[11] and is known to affect DNA causing point mutations and chromosome aberrations.[11]

Dieldrin has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

DIELDRIN

SYNONYMS = Compound 497, Octalox, Alvit, Quintox, Dieldrite, 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8, 8a-Octahydro-Endo-Exo-1,4:5,8-Dimethanonaphthalene

PRODUCTION QUANTITY = 670,000 lbs - 1970

IATA = Other restricted articles, Class A, no label required

M.P. 175°C

Sp. G. = 1.75

SOLUBILITY = .186 ppm

PERSISTENCE

Oxygen Demand = Highly resistant to biochemical oxidation.

Chemical Hydrolysis, etc. = Affected by strong mineral acids.[2]

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
.008	96	Bass	TLm		1
.008	96	Goldfish	TLm		1
.01	96	Bluegill	TLm		1
.025	96	Goldfish	80% Kill		1
.02	48	Trout	100% Kill		1
0.5	96	Catfish	TLm		329
.019	96	Guppy	TLm		329
5.0	-	Carp Embryo	50-100% Mortality		311
.016	96	Fathead Minnow	TLm		330
.0079	96	Bluegill	TLm		330
.037	96	Goldfish	TLm		330
.022	96	Guppies	TLm		330
.006	24	Rainbow	LC_{50}		330
.014	24	Bluegill	LC_{50}		330
.010	24	Rainbow	LC_{50}		330
.015	48	Rainbow	LC_{50}		330
.013	96	Rainbow	LC_{50}		330
.0055	24	Bluegill	LC_{50}		330
.0034	48	Bluegill	LC_{50}		330

ppm	hrs	Species	Parm	Cond.	Ref.
.0028	96	Bluegill	LC_{50}		330
.056	24	Bluegill	LC_{50}	Temp. 45°F	330
.034	48	Bluegill	LC_{50}	Temp. 45°F	330
.016	96	Bluegill	LC_{50}	Temp. 45°F	330
.040	24	Bluegill	LC_{50}	Temp. 55°F	330
.026	48	Bluegill	LC_{50}	Temp. 55°F	330
.018	96	Bluegill	LC_{50}	Temp. 55°F	330
.024	24	Bluegill	LC_{50}	Temp. 65°F	330
.018	48	Bluegill	LC_{50}	Temp. 65°F	330
.0165	96	Bluegill	LC_{50}	Temp. 65°F	330
.014	24	Bluegill	LC_{50}	Temp. 75°F	330
.011	48	Bluegill	LC_{50}	Temp. 75°F	330
.003	96	Bluegill	LC_{50}	Temp. 75°F	330
.010	24	Bluegill	LC_{50}	Temp. 85°F	330
.0084	48	Bluegill	LC_{50}	Temp. 85°F	330
.0071	96	Bluegill	LC_{50}	Temp. 85°F	330
.008	96	Bluegill	LC_{50}		331
.05	24	Rainbow	LC_{50}		331
.25		Goldfish	LC_{50}		331
.330	50	Daphnia Magna	LC_{50}		331
2.5		Lymnaeid Snails	100% Lethal	Ditch Water	106
.04 lb/acre		Blackfly Larvae	Lethal	Streams	415
2.5	25	Channel Catfish	Lethal	Tap Water	223
.33	50	Daphnia Magna	Immobilized		365
.0108	96	Coho	TLm	In Acetone	342
.0061	96	Chinook	TLm	In Acetone	342
.0099	96	Rainbow	TLm	In Acetone	342
.0153	96	Threespine Stickleback	TLm	In Acetone	342
.5	1	Gammarus Lacustris	50% Lethal		343
.5	24	Catespeiana Tadpoles	100% Lethal	Ponds	344
.0067	96	Pumpkinseed	TLm		416
.039	96	Pteronarcys Californica (Naiad)	TLm	In Acetone	367
.024	96	Acroneuria Pacifica	TLm	In Acetone	367

ppm	hrs	Species	Form	Cond.	R.F.
.7	96	Gammarus Lacustris	Tlm	In Acetone	350
50-135	36	Palaemonetes Kadiakensis	Tlm	Nonagricultural and agricultural areas respectively	368
.003-.020	72	Black Bullhead	Tlm	Miss. R.	368
.001-.025	72	Mosquito Fish	Tlm	Miss. R.	368
.008	96	Ephemerella Grandis	Tlm	Soft Water	333
.021	96	Poecilia Reticulata	Tlm	Soft Water	417
.25	48	Simocephalus Serrulatus	EC_{50}		354
.740	64	Daphnia Magna	Immobilized	Temp. 70°F	335
.250	64	Daphnia Carinata	Immobilized	Temp. 70°F	335
.240	64	Simocephalus Serrulatus	Immobilized	Temp. 70°F	335
.250	64	Daphnia Pulex	Immobilized	Temp. 70°F	335
6-71	96	Tubifex Limnodrilus Spp	LD_{50}		362
12.8	120	Algae Diatoms	Tlm		410
.0005	96	P. Californica (Naiads)	Tlm		184
.0005	96	Pteronarcella Badia (Naiads)	Tlm		184
.00058	96	Claassenia Sabulosa (Naiads)	Tlm		184

Saltwater Toxicity

ppm	hrs	Species	Form	Cond.	R.F.
0.05	5	Mullet	100% Kill		1
0.595	5	Shrimp Larvae	Tlm		1
0.012	168	Sailfin Molly	100% Kill		419
0.025-0.05	48	Brown Shrimp	Tlm		330
0.025-0.05	48	White Shrimp	Tlm		330
1.172	24	Brine Shrimp	Lethal	Book 1	383
5.65	96	Grass Shrimp	LC_{50}		415

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	81	Oral	1
Dog	68	Oral	340
Rat	60	Oral	1
Rat	46	Oral	96

DIETHYLAMINE

Diethylamine is used to produce resins, dyes, flotation agents, detergents, and pharmaceuticals as well as for vulcanizing rubber. The 9,900,000 lbs produced in 1969 (199) were shipped in glass bottles, 1-5 gal cans, 55 gal steel drums, and tank cars.

Diethylamine is typically shipped as an aqueous solution and is soluble in water in all proportions. It has a strong alkaline reaction in water which is believed to result from dissociation of the amine group to form an ammonium ion. Under strong alkaline conditions, ammonia gas may be released. No data exists on the biodegradability of diethylamine but it is likely to occur at a moderate rate much as the butylamines. No oxygen deficiencies are expected to occur in a spill situation.

Investigations into the toxicity of diethylamine to fish indicate it to be a greater hazard than diethanolamine. The critical range for creek chub is reported as 30-100 ppm in a 24 hour period (1). Fish food organisms are susceptible to concentrations of 4-100 ppm (1). The pH and buffer capacity of receiving waters are likely to be critical parameters in determining resulting toxicity.

Diethylamine is a severe irritant which can be highly toxic when ingested. Acute toxicity in mammals falls in the LD50 range of 500-599 mg/Kg (15). Rabbits fed 6 mg/Kg/day for 7 months showed a disturbance in the carbohydrate function of the liver. Rats fed 64.8 mg/kg/day for 2.5 months showed a decrease in weight gain and an increase in ascorbic acid content of liver. The threshold odor concentration for diethylamine is 4.2 mg/l (1).

NAME Diethylamine

PRODUCTION QUANTITY 9,000,000 lbs 1969 (199)

COMMON SHIP OR CONTAINER SIZE glass bottles, 1-5 gal cans, 55 gal steel drums, tank cars

M.P. -38.9 °C

B.P. 55.5°C

Sp.G. 0.71

SOLUBILITY Soluble - 815,000 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
85	24	Chub	TLm	Aerated, 15-21°C	1
4	96	Scenedesmus	Toxic		1
100	48	Daphnia	Toxic	23°C	1
70	48	Microregma	Toxic		1
100	24	Chub	Died	Aerated, 15-21°C	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	540	Oral	15
Mouse	648.6	Oral	15

DIMETHYLAMINE

Dimethylamine is used in tanning leather, vulcanizing rubber, and manufacturing soaps and detergents. The 78.3 million lbs produced in 1970 (198) were shipped both as a gas and in solutions. In the former case steel cylinders, tank cars, and tank trucks were employed; while steel drums, tank cars, tank trucks, and tank barges were required for the latter.

Dimethylamine is highly soluble in water, yielding a strongly alkaline solution. If spilled as a solution, contact with water will lead to rapid spreading of the plume. If spilled as a gas, only minimal amounts are likely to be dissolved in the water. The alkalinity is believed to be a direct result of dissociation of the amine group to form an ammonium ion. Strong alkaline conditions could lead to release of ammonia gas. Evaluations of biochemical oxygen demand indicate no oxygen utilization in five days (64). Degradation has been noted however with a resultant release of ammonia (64).

Dimethylamine displays toxicity to creek chub at the 50 ppm level (1). Rainbow trout died after 10 minutes in a solution of 205 ppm (1). Warmblooded organisms display no effects to water with 0.14 ppm (99). In saltwater, Portmann reports an LC50 of greater than 100 ppm for shrimp(2).

Because of the alkaline reaction, solution pH and buffer capacity of receiving waters are likely to be critical parameters in determining resulting toxicity.

Dimethylamine can be toxic when inhaled or ingested. Acute oral toxicity as denoted by LD50 is reported to fall in the range 200-299 mg/Kg for mammals (15). The threshold for chronic exposure to rats is .007 mg/Kg body weight or .14 mg/l drinking water (15).

Other aquatic concentrations of interest include an odor threshold range of .01-42.5 ppm (30). Dimethylamine can be detected by taste at 0.6 ppm (4).

NAME Dimethylamine

PRODUCTION QUANTITY 78.3 million lbs 1970 (190)

COMMON SHIP OR CONTAINER SIZE gas: steel cylinders, tank cars, tank trucks
solutions: steel drums, tank cars, tank trucks, tank barges

DOT Anhydrous: Flammable gas, Red Gas Label, 300 lbs outside container
Aq. Solution: Flammable liquid, Red Label, 10 gal outside container

USCG Inflammable gas or liquid red label

M.P. -96. °C

B.P. 7.4 °C

Sp.G. 0.680

SOLUBILITY Very soluble

PERSISTENCE

Oxygen Demand

BOD_5 = 0-(64)
COD = 0-(64)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
50	24	Chub	Died	Aerated 15-21°C	1
85	48	Chub	TLm		15
0.14		Warm Blood Organisms	No Effect		99
205	.5	Rainbow Trout	Survival Time	pH 10.3, 13°C	1

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
>100	48	Shrimp	LC50	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	698	Oral	15
Mouse	640.5	Oral	15

DINITROBENZENE

Dinitrobenzene is typically shipped in steel barrells, wooden boxes containing four 25 cans, and fiber drums with up to 100# capacity. Dinitrobenzene may also be shipped in solution.

Dinitrobenzene has a very limited solubility. When spilled, the crystals will sink and dissolve very slowly. No biochemical oxygen demand data are given for dinitrobenzene. However, nitrobenzene is resistant to microbial attack and the dinitro compound is expected to act similarly.

Fish respond to dinitrobenzene at very low levels. The 6 hour MLD for minnows is reported as 8-10 ppm (1). Use of distilled water raised that value to 10-12 ppm suggesting that water hardness effects toxicity (1). Other sources report a lethal level to fish of 2 ppm (1). A concentration of 100 ppm killed less than 100 percent of lymnaeid snails tested (108). Undissolved solids on the bottom threaten spawning grounds and benthic life forms.

Dinitrobenzene is considered highly toxic by all routes. It can be absorbed through the skin. The reported LD50 value for oral administration to rats is 83.4 mg/kg body weight using the para-isomer (8).

DINITROBENZENE

USCG - Poison Label

IATA - Poison Label

M.P. - meta - 89.8°C

ortho - 117.9°C

para - 172-173°C

B.P. - meta - 302.8°C

ortho - 319°C

para - 299°C

Sp.G. - meta - 1.546

ortho - 1.565

para - 1.6

TOXICOLOGICAL

FRESHWATER TOXICITY

100/ /Lymnaid snails/ 100% killed/ /106

10-12/6/Minnows/MLD/Distilled, 23°C/1

8-10/6/Minnows/MLD/Hard, 23°C/1

2/ /Fish/Lethal level/ /1

MAMMALIAN TOXICITY

Species	mg/kg B.W.	Administration Route	Ref.
Cat	29	LDLO	8

DINITROPHENOL

Dinitrophenol is used as a wood preservative, dye base, indicator, and analytical agent. Approximately 1,037,000 lbs were produced in 1964 (199).

Dinitrophenol is sparingly soluble in water. The crystals will sink if spilled into water and dissolve slowly. The sodium salt may soon form and accelerate dissolution. The dissolved portion is subject to limited biodegradation. Phenol acclimated seed can utilize 7.7 percent of the theoretical oxygen demand in .94 days (5). This will be retarded at most spill concentrations however, since 100 ppm can cause a 50 percent inhibition of oxygen utilization. No oxygen deficiencies will develop in a spill situation.

Dinitrophenol can be lethal to fish at 30 ppm (1). Fish food organisms die in the concentration range 6-100 ppm (1,106). Water hardness appears to be antagonistic to the toxicity of dinitrophenol. Minnows exposed to 15-18 ppm in hard water overturn within 6 hrs, while in distilled water a similar reaction occurs at 0.5-1.0 ppm (1). In general, phenols have a threshold concentration to fish of 1 ppm in freshwater and 5 ppm in saltwater (41).

Dinitrophenol, like most phenols, is highly toxic by all routes including skin absorption. The median lethal dose for rats is reported to be 30 mg/Kg body weight (8). For chronic administration, the threshold in rats is .031 mg/Kg or .6 mg/l in drinking water (15).

For fresh water where body contact is probable, phenols should be kept below 50 ppm (41). For prolonged contact in salt water, the limit is 7 ppm (41). Drinking water should not contain more than .001 ppm for taste purposes (49). Waterfowl can be harmed by water with a concentration greater than 25 ppm (41).

NAME Dinitrophenol

PRODUCTION QUANTITY 1,037,000 lbs 1964 (199)

SYNONYMS 2,4-Dinitrophenol, α-Dinitrophenol

DOT Solutions: Class B Poison, Poison Label, 65 lbs outside container

M.P. 112 °C Sublimes

B.P. 112 °C Sublimes

Sp. G. 1.683

SOLUBILITY 13,200 mg/l 54°C

PERSISTENCE

Oxygen Demand

BOD$_{24}$ = 7.7% Theo. with phenol acclimated pure bacterial culture (5)

Chemical Hydrolysis, etc.

Forms soluble sodium salt.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
200	.1	Minnow	Dead	Neutral	1
6		Daphnia	Toxic	21°C	1
40		Scenedesmus	Toxic	24°C	1
>100		E. Coli	Toxic	27°C	1
100		Lymnaied Snails	>100% Kill		106
10		Minnows	MLD		1
35-38	6	Minnows	Overturn	Hard	1
0.5-1.0	6	Minnows	Overturn	Distilled	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	30	Oral	8

DIQUAT

Diquat is the name given a group of pyrazidinium salts employed as herbicides. The dibromide salt is the most commonly used, and is applied to control aquatic weeds as well as flowers and terrestrial weeds. It is typically applied as a solution.

Diquat is highly soluble in water (70,000 ppm) and will spread quickly when apilied. It is not very persistent, however. When applied in ponds at 2.5 ppm, it persisted for 7-27 days.[22] Diquat is strongly absorbed on soil particles and subsequently deactivated.[515]

Diquat is moderately toxic to aquatic life. The 96 hour TLm values for bluegill and fathead minnow are 140 ppm and 130 ppm, respectively, in hard water. Values for soft water are much lower.[557] Lawrence, et al.,[183] have reported the 96 hour threshold concentration to be 10 ppm for bluegill, smallmouth bass, fathead minnows, and channel catfish and 5 ppm for rainbow trout. Daphnia magna are immobilized by 7.1 ppm.[22] When present in fish, 50 percent of the residual Diquat was lost in less than 3 weeks.[22]

In salt water, 1 ppm has no effect on longnose killifish, oysters or white shrimp.[22] Portmann[7] found the 48 hour LC_{50} to be greater than 16 ppm for shrimp and cockles.

There is no specific human toxicity data for Diquat, but fatal poisonings have occurred from the related compound--paraquat. The oral LD_{50} for rats is reported to be 400-440 mg/kg body weight while that for young mallards is 564 mg/kg body weight.[22]

DIQUAT

SYNONYMS - 6,7-Dihydrodipyridol (1,2-a: 2,', 1'-C) Pyrazidinium Dibromide, Aquacide, Dextrone, Reglone

M.P. 335-340°C

SOLUBILITY - 700,000 ppm @ 20°C

PERSISTENCE

Oxygen Demand - Degrade moderately fast

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
2.5	72	Bluegill Fry	Survived		22
2.5	48	Lake Chub-Sucker Fry	Survived		22
2.5	24	Smallmouth Bass Fry	Survived		22
15.5	24	Lake Emerald Shiner	LC_{50}	Dichloride	22
34	24	Largemouth Bass	LC_{50}	Salt	22
78	24	Harlequin Fish	LC_{50}	Dibromide	22
90	24	Rainbow Trout	LC_{50}	Dibromide	22
91	24	Bluegill	LC_{50}	Salt	22
140	24	Fathead Minnow	LC_{50}	Salt	22
180	24	Lake Emerald Shiner	LC_{50}	Dibromide	22
315	24	Striped Bass	LC_{50}	Salt	22
12.3	48	Rainbow Trout	LC_{50}	Salt	22
28.5	48	Chinook Salmon	LC_{50}	Salt	22
7.1		Daphnia Magna	Immobilization		22
1-10	96	Bluegill	LC_{50}	Hard	402
72	96	Bluegill	LC_{50}	Hard	402
130	96	Fathead Minnow	LC_{50}	Hard	402
14	96	Fathead Minnow	LC_{50}	Soft	402
14-78	96	Smallmouth Bass	LC_{50}	Soft	402
9-10	96	Bluegill	Threshold Concentration		402
10	96	Smallmouth Bass	Threshold Concentration		402
10	96	Fathead Minnow	Threshold Concentration		402
10	96	Channel Catfish	Threshold Concentration		402

ppm	hrs	Species	Parm	Cond.	Ref.
5	96	Rainbow Trout	Threshold Concentration		402
35	96	Bluegill	LC_{50}		402
35	96	Goldfish	LC_{50}		402
16	96	Northern Pike	LC_{50}		402
11.2	96	Rainbow Trout	LC_{50}		402
2.1	96	Walleye	LC_{50}		402

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond	Ref.
1	48	Longnose Killifish	No Noticeable Effect		22
1	96	Oysters	No Noticeable Effect		22
1	48	White Shrimp	No Noticeable Effect		22
>10	48	Shrimp	LC_{50}		2
>10	48	Cockle	LC_{50}		2

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	400-440	Oral	22
Rat	121	Oral	96

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	564	Oral	22
Mallards	>5000 ppm	LC_{50}-5 days	22
Pheasants	3600-3900 ppm	LC_{50}-5 days	22
Coturnix	1400-1600 ppm	LC_{50}-5 days	22

DISULFOTON

Disulfoton, or Disyston, is an organophosphate systemic insecticide and acaricide. The 8 million lbs produced in 1971 were used as a furrow side dressing and broadcast agent to control insects pests, especially sucking insects. It is typically applied as granules, liquid concentrates, fertilizers impregnate, or seed treatment powder.

Disulfoton is a pale yellow liquid soluble to 25 ppm in water. It may persist in soil for 4 weeks after application.[1] Degradation is similar to that for other organophosphates. Alkaline conditions can lead to hydrolysis.[1] Upon spillage, the liquid is likely to sink and become associated with bottom sediments where it will soon degrade.

Disulfoton is toxic to aquatic life. The 96 hour LC_{50} for bluegill is 0.064 ppm in hard water and 0.07-0.082 in soft water.[5] In soft water, the 96 hour LC_{50} values for goldfish, guppy, and fathead minnows are 7.2 ppm, 0.28 ppm, and 4.1 ppm respectively.[6] Fish food organisms may also be affected. The 96 hour LC_{50} for food chain organisms P. californica, Acroneuria pacifica, Ephemerella grandis, and Gammarus lacustris are 0.03 ppm, 0.008 ppm, 0.08 ppm, and 0.2 ppm respectively.[1]

Like many other organophosphates, Disulfoton is a cholinesterase inhibitor. The oral LD_{50} for rats is 12.5 mg/kg body weight while that for young mallards is 6.5 mg/kg body weight.[1]

DISULFOTON

SYNONYMS - Disyston, Thiodemeton, Bay 19639, Dithiodemeton,
Dithiosystox, Frumin Al, Solvirex, O,O-Diethyl S-
(2-(ethylthio) ethyl) phosphorothioate

PRODUCTION QUANTITY - 8,000,000 lbs - 1971

B.P. 62°C at 1 mm

Sp. G. - 1.144

SOLUBILITY - 25 ppm

PERSISTENCE

Oxygen Demand - Biodegrades

Chemical Hydrolysis, etc. - Hydrolyzes under alkaline conditions(1)

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
0.04	48	Bluegill	LC$_{50}$		22
0.06	24	P. Californica (Nymphs)	LC$_{50}$		22
18	48	P. Californica	LC$_{50}$		22
70	48	Gammarus Lacustris	LC$_{50}$		22
0.11	24	Gammarus Lacustris	LC$_{50}$		22
1.7	96	Fathead Minnow	LC$_{50}$		402
0.064	96	Bluegill	LC$_{50}$		402
7.2	96	Goldfish	LC$_{50}$	Soft in Acetone	402
0.28	96	Guppy	LC$_{50}$	Soft in Acetone	402
0.082	96	Bluegill	LC$_{50}$	Soft in Acetone	402
0.03	96	P. Californica	LC$_{50}$	Soft	402
0.008	96	Acroneuria Pacifica	LC$_{50}$	Soft	402
0.08	96	Ephemerella Grandis	LC$_{50}$	Soft	402
0.2	96	Gammarus Lacustris	LC$_{50}$	Soft	402
0.07	96	Bluegill	LC$_{50}$	Soft	402
4.1	96	Fathead Minnow	LC$_{50}$	Soft	402

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	17.5	Oral	22
Goats	<15	Oral	22
Rat	10	Oral	96

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	6.5	Oral	22
Mallards	400-500 ppm	LC_{50}-5 days	22
Pheasants	600-700 ppm	LC_{50}-5 days	22
Bobwhites	700-800 ppm	LC_{50}-5 days	22
Coturnix	300-400 ppm	LC_{50}-5 days	22

DIURON

Diuron is a selective herbicide of the phenyl urea group. The 6 million lbs produced in 1971 were used at limited dosage for controlling seedling weeds and grasses in numerous crops, and at higher doses as a soil sterilant. It is typically applied as an 80 percent wettable powder or a 28 percent water suspension.

Diuron is a white solid soluble to 42 ppm in water. It is quite persistent. In moist-loam soil 1-3 lb/acre persisted for 3-6 months under temperate summertime conditions with little or no leaching. Applications of 2 lb/acre have persisted more than 15 months, and residues have been found in vegetation for 95 days and mud for 122 days after pond treatment at 0.5-20 ppm.[11]

Diuron is moderately toxic to aquatic life. The 96 hour LC_{50} for Bluegill is reported as 4.0 ppm.[110] The 48 hour EC_{50} for rainbow trout is 4.3 ppm.[115] Fish food organisms such as P. californica display a 96 hour LC_{50} of 0.0012 ppm.[105] In saltwater, the 48 hour TLm for hard clam eggs is 2.5 ppm[111] and the 96 hour EC_{50} for oysters is 1.8 ppm.[11]

Limited animal experiments suggest that diuron is only moderately toxic. The oral LD_{50} for rats is 3400 mg/kg body weight.[1] Carcinogenisis studies have been negative in rats[11] but Diuron is suspected of affecting DNA.[12] No teratogenicity has been reported.[12]

DIURON

SYNONYMS - Di-on, Diurex, Karmex, Marmer, Dichlorfenidim,
3-(3,4-Dichlorophenyl)-1,1-dimethylurea, Krovar,
1,1-Dimethyl-3,4-Dichlorophenyl urea

PRODUCTION QUANTITY - 6,000,000 lbs - 1971

M.P. 158-159°C

B.P. 180° Decomposes

SOLUBILITY - 42 ppm

PERSISTENCE

Oxygen Demand - Moderately persistent

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Para	Cond.	Ref.
16	48	Coho Salmon	50% Kill		1
5-10		Bass, Bluegill	Partial Kill	Pond	1
10		Bass, Bluegill	Total Kill	Pond	1
33	24	Coho Salmon	TLm		110
12	24	Bluegill	LC_{50}		110
7.4	48	Bluegill	LC_{50}		110
4.0	96	Bluegill	LC_{50}		110
4.3	48	Rainbow Trout	EC_{50}		154
1.4	48	Daphnia Pulex	EC_{50}		154
2	48	Simocephalus Serrulatus	EC_{50}		154
16	48	Salmon	LC_{50}		20
0.0012	96	P. Californica (Naiads)	LC_{50}		184

Saltwater Toxicity

ppm	hrs	Species	Para	Cond.	Ref.
1.0	24	Brown Shrimp	No Effect		110
1.0	48	Brown Shrimp	No Effect		110
0.004- 0.04		Marine Plankton	Lethal or no Growths		95
1.8	96	Oyster	EC_{50}		23
6.3	48	Striped Mullet	EC_{50}		23
1	4	Phytoplankton	87% inhibition		23
2.5	48	Hard Clam Eggs	TLm		411
>5.0	288	Hard Clam Larvae	TLm		411

[illegible]

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	3800	Oral	1
Rat	1700	Oral	129
Rat	437	Oral	96
Mice	500	Low Lethal Dose - Intraperitoneal	96

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	>2000	Oral	22
Mallards	>5000 ppm	LC_{50}-5 days	22
Pheasants	>5000 ppm	LC_{50}-5 days	22
Bobwhites	2000-2200 ppm	LC_{50}-5 days	22
Coturnix	>5000 ppm	LC_{50}-5 days	22

DURSBAN

Dursban is a broad spectrum insecticide used to control turf pests, ornamental plant pests, household and premise pests, and mosquitoes. The 5 million lbs produced in 1971 were applied as granules and emulsifiable concentrates.

Dursban is a white granular crystal soluble to 2 ppm in water. Persistence data is not well defined, but nearly half is lost from fish flesh in less than one week.[11] When spilled, it is likely to sink to the bottom and degrade.

Dursban is relatively toxic to aquatic life. The 48 hour LC_{50} for rainbow trout is 0.02 ppm and goes up in concentration as temperature decreases to 1.6°C.[11] The 24 hour LC_{50} values for fish food organisms Gammarus lacustris, Pteronarcella badia, Claassenia sabulosa, and P. californica are 0.00076 ppm, 0.0043 ppm, 0.0082 ppm, and 0.05 ppm respectfully.[22]

Dursban is moderately toxic to mammals -- oral LD_{50} in rats 135 mg/kg body weight, and quite toxic to birds. The oral LD_{50} for many game birds falls in the range 8.4-80 mg/kg body weight.[22]

DURSBAN

SYNONYMS - Chlorpyrifos, Dowco 179, O,O-Diethyl O-(3,5,6-Trichloro-2-Pyridyl) Phosphorothioate

PRODUCTION QUANTITY - 5,000,000 lbs - 1971

M.P. 41.5-43.5°C

SOLUBILITY - 2 ppm at 25°C

PERSISTENCE

Oxygen Demand - Degradable

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Para	Cond.	Ref.
.550	24	Rainbow Trout	LC_{50}	1.6°C	22
.110	24	Rainbow Trout	LC_{50}	7.2°C	22
.051	24	Rainbow Trout	LC_{50}	12.7°C	22
.020	48	Rainbow Trout	LC_{50}		22
0.00076	24	Gammarus Lacustris	LC_{50}		22
0.0042	24	Pteronarcella Badia	LC_{50}		22
0.0081	24	Claassenia Sabulosa	LC_{50}		22
0.05	24	P. Californica	LC_{50}		22
0.0004	48	Gammarus Lacustris	LC_{50}		22
0.0018	48	Pteronarcella Badia	LC_{50}		22
0.045	36	Golden Shiners	TLm	Lab	22
0.125	36	Golden Shiners	TLm	Acclimated	22
0.23	36	Mosquito Fish	TLm	Lab	22
0.595	36	Mosquito Fish	TLm	Acclimated	22
0.038	36	Bluegill	TLm	Lab	22
0.125	36	Bluegill	TLm	Acclimated	22

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	135	Oral	22
Goat	500-1000	Oral	22
Rat	145	Oral	96

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Mallards	70-80	Oral	22
Young Pheasants	8.4-17.7	Oral	22
Young Chicken Partridges	61	Oral	22
Young Coturnix	16-18	Oral	22
Pigeons	26.9	Oral	22
House Sparrows	21	Oral	22
Canada Geese	≥80	Oral	22
Lesser Sandhill Cranes	25-56	Oral	22
Coturnix	275-300 ppm	LC_{50}-5 days	22

Endosulfan

Endosulfan, or Thiodan, is an insecticide used on foliage eating pests on deciduous, citrus and small fruits, as well as vegetables and general foliage. The 2 million lbs produced in 1971 were applied as 50 percent wettable powder, 1-4 percent emulsifiable concentrates, 3 percent granules, and in combination with other insecticides.

Endosulfan is a mixture of two solid isomers with a very low solubility in water. Alkaline conditions lead to hydrolysis. While specific data are not published, degradability is considered high. Upon spillage, endosulfan should sink and undergo biochemical oxidation.

Endosulfan is quite toxic to aquatic life. The 96 hour LC_{50} values for fathead minnow and guppy are reported to be 0.001 ppm and 0.0037 ppm respectively.[157] The 24 hour LC_{50} values for rainbow trout and harlequin fish are 0.012 ppm and 0.00002 ppm respectively.[22] Fish food organisms such as Gammarus lacustris, Daphnia pulex, and P. californica have 48 hour LC_{50} values of 0.064 ppm, 0.240 ppm, and 0.0056 ppm respectively.[22] In saltwater, the 48 hour LC_{50} for shrimp has been found to be 0.01 ppm and that for pogge 0.03-1.0 ppm.[7]

Endosulfan is also toxic to high forms of life. The oral LD_{50} to rats varies from 30 to 70 to 110 mg/kg body weight when administered in alcohol, aqueous, and oil solutions respectively.[115] For mallards, the oral LD_{50} is reported to be 33 mg/kg body weight.[22]

ENDOSULFAN

SYNONYMS - 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-Hydro-
6,9-Methano-2,4,3-Benzo (e)-Dioxathiepin-3-Oxide,
Chlorthiepin, Cyclodan, Hoe 2671, Insectophene,
Bop-Thiodan, Malix, Thifor, Thimul, Thionex, Thiodan

PRODUCTION QUANTITY - 2,000,000 lbs - 1971

M.P. 70-100°C

Sp. G. - 1.745 @ 20°C

SOLUBILITY - Practically insoluble in water

PERSISTENCE

Oxygen Demand - Degradable

Chemical Hydrolysis, etc. - Hydrolyses in alkali

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
0.013	24	Rainbow Trout	LC_{50}		22
0.0081	24	Rainbow Trout	LC_{50}		22
0.0032	24	Rainbow Trout	LC_{50}		22
0.0012	48	Rainbow Trout	LC_{50}		22
0.00002	24	Harlequin Fish	LC_{50}		22
0.0092	24	Gammarus Lacustris	LC_{50}		22
0.024	24	P. Californica	LC_{50}		22
0.0056	48	P. Californica	LC_{50}		22
0.064	48	Gammarus Lacustris	LC_{50}		22
0.240	48	Daphnia Pulex	LC_{50}		22
0.01	24	Smallmouth Bass	Lethal to 50%		402
0.005	5	Carp	Lethal		402
0.0033	96	Fathead Minnow	LC_{50}		402
0.0037	96	Guppy	LC_{50}		402

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
0.03-1.0	48	Pogge	LC_{50}		2
>10	48	Cockle	LC_{50}		2
0.01	48	Shrimp	LC_{50}		2

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	20 in Alcohol	Oral	414
Rat	70 in Alcohol	Oral	414
Rat	110 in Oil	Oral	414
Rat	100	Oral	8

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	33	Oral	22
Mallards	900-1100 ppm	LC_{50}-5 days	22
Pheasants	1200-1350 ppm	LC_{50}-5 days	22
Bobwhites	800-900 ppm	LC_{50}-5 days	22
Coturnix	2100-2250 ppm	LC_{50}-5 days	22

ENDRIN

Endrin is one of the polychlorinated aromatic insecticides. The less than one million lbs produced in 1971 (327) were applied as dust, granules, wettable powder, and emulsion concentrates on crops including cotton, corn, and cabbage.

Endrin is insoluble in water, but may disperse rapidly if spilled in a wettable form. Once spilled, it is reported to be non-persistent. On the other hand, some researchers claim 100 percent remained in river water after 8 weeks (328). Iyatomi claims toxicity persists over 1 month in rice paddies (1). In soil, Mulla reports residues after more than 9 years. Endrin applied to soil at 25 ppm underwent 50 percent loss in 12 years. When applied to sandy loam at 100 ppm, 41 percent remained after 14 years (22). It would appear that endrin hydrolyses to some extent, and persistence is a function of the moisture content of the immediate environment.

Endrin is highly toxic to aquatic life. The 96 hr LC50 for rainbow trout is .00086 ppm, while that for bluegill is .00025 ppm (330) and that for fathead minnows is .0018 ppm (331). Daphnia magna are immobilized in 50 hrs when exposed to .152 ppm (365). Other fish food organisms are similarly affected by .02-.05 ppm (335). The 72 hr Tlm for crawfish has been reported as .3 ppm (366). In salt water, the 24 hr Tlm for shrimp is .0006 ppm (23). Juvenile spot have been killed by .0001 ppm and juvenile longnose killifish by .000079 ppm (23). Oysters display sublethal effects at .01-1.0 ppm (404).

Fish can accumulate endrin from water. Fathead minnows exposed to .015 ppb concentrated endrin 10,000 times. Similarly, oysters can concentrate endrin by a factor of 1000 after 10 days exposure to .001 ppm. Algae has also been found to contain 170 times the concentration of surrounding waters (22). While carp were found to undergo similar accumulation, the accumulative toxic effects have not been noted in the host. The cumulative toxicity index is 4.5 (165).

In addition to being highly toxic to fish, endrin is also quite hazardous to warm blooded animals. The oral LD50 values for rats and monkeys have been reported as 7.3 and 3 mg/kg body weight, respectively (1). In chronic feeding studies, as little as 4 mg/kg/day caused abnormal effects in dogs (1). Drinking water should not contain more than .001 ppm endrin (337). Endrin may be mutagenic; barley given 1000 ppm for 12 hrs developed point mutations (15). Endrin is known to effect DNA causing chromosome aberrations (19).

Birds display low tolerance to endrin. The computed oral LD50 values for mallards and young pheasants are 5.6 and 1.8 mg/kg body weight, respectively (22). Quail fed 1 mg/kg/day suffered a 40 percent reduction in reproduction (1).

Endrin is also phytotoxic. Productivity of phytoplankton was reduced 46 percent when exposed to 1 ppm endrin for 4 hours. Doses of 10 and 100 ppm in soil endrin were sufficient to reduce bean growth 13 percent over an 8 week period. Doses as low as 1 ppm caused significant changes in macro and micro nutrient levels in corn and beans (22).

Endrin has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

NAME Endrin

PRODUCTION QUANTITY <1 million lbs - 1971

SYNONYMS 1,2,3,4,10,10-Hexachloro-6,7-Epoxy-1,4,4a,5,6,7,8,8a-Octahydro-1,4-Endo-Endo-5,8-Dimethanonaphthalene; Mendrin; Compound-269

M.P. 200 °C

B.P. 245 °C

SOLUBILITY Insoluble - 0.23 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
.005	48	Carp	TLm		1
.051	96	Salmon	TLm		1
.0006	96	Bluegill	TLm		1
.001	24	Guppies	100% Kill		1
.0019	96	Goldfish	TLm		329
.0015	96	Guppies	TLm		329
5.0		Carp Embryo	50-100% Mortality		341
.0013	96	Fathead	TLm		330
.001	96	Fathead	TLm		330
.0007	24	Rainbow	LC50		330
.0008	24	Bluegills	LC50		330
.0018	24	Rainbow	LC50		339
.0012	48	Rainbow	LC50		330
.10006	96	Rainbow	LC50		330
.00038	24	Bluegill	LC50		330
.00027	48	Bluegill	LC50		330
.00025	96	Bluegill	LC50		330
.0008	24	Bluegill	LC50	Temp 45°F	330
.0018	48	Bluegill	LC50	Temp 45°F	330
.0007	96	Bluegill	LC50	Temp 45°F	330
.0038	24	Bluegill	LC50	Temp 55°F	330
.0018	48	Bluegill	LC50	Temp 55°F	330
.0007	96	Bluegill	LC50	Temp 55°F	330
.0014	24	Bluegill	LC50	Temp 65°F	330
.0007	48	Bluegill	LC50	Temp 65°F	330
.0006	96	Bluegill	LC50	Temp 65°F	330
.0008	24	Bluegill	LC50	Temp 75°F	330
.0008	48	Bluegill	LC50	Temp 75°F	330

ppm	hrs	species	parm	cond	ref
.0004	96	Bluegill	LC50	Temp 75°F	330
.0003	24	Bluegill	LC50	Temp 65°F	330
.0002	48	Bluegill	LC50	Temp 85°F	330
.0002	96	Bluegill	LC50	Temp 85°F	330
.00027	96	Coho	LC50		331
.0018	96	Fathead	LC50		331
.14	48	Carp	LC50		331
.352	50	Daphnia Magna	Immobilized		365
.00051	96	Coho	TLm	In Acetone	342
.0012	96	Chinook	TLm	In Acetone	342
.00058	96	Rainbow	TLm	In Acetone	342
.00044	96	Threespine Stickleback	TLm	In Acetone	342
.00075	96	Mosquito Fish	TLm	Temp 20°C	342
.00825	96	Mosquito Fish	TLm	Temp 5°C	342
.5	.5	Gammarus Lacustris	LT50		343
.5/lb acre	24	Lacustris Cutesbriana Tadpoles	100% Lethal	Pond	144
.3	72	Crawfish	TLm		366
.0024	96	P. Californica (Naiad)	TLm		367
.00039	96	Acroneuria Pacifica (Naiad)	TLm		367
.0115	96	Gammarus Lacustris	TLm		358
.00086	96	Rainbow	LC50		303
6.5-9.5	36	Palaemonetes Kadiakensis	TLm	Non ag. & ag. areas respect.	368
.0004- .002	72	Black Bullhead	TLm	Miss. R.	368
.005	96	Ephemerella Grandis	TLm	Soft	333
.05	64	D. Carinata	Immob.	Temp 70°F	335
.036	64	Simocephalus Serrulatus	Immob.	Temp 70°F	335
.020	64	D. Pulex	Immob.	Temp 70°F	335
.8	64	D. Magna	Immob.	Temp 70°F	335

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
.0025	48	Brown Shrimp	TLm		330
.0065	48	White Shrimp	TLm		330
.0006	24	Shrimp	50% Lethal		21
.0031	96	Puffer Fish	TLm		416

ppm	hrs	species	parm	cond	ref
.0001	120	Juvenile Spot	Lethal		33
.000079	24	Juvenile Longnose Killifish	EC50	Temp 21°C	33
.00045	24	Spot	LC50		364
.0026	24	Striped Mullet	LC50		364
.0008	24	Brevoortia Patronus	LC50		364
.00023	24	Longnose Killifish	LC50		364
.00032	24	Sheepshead Minnow	LC50		364
.01-1.0		Oyster	Sublethal Effects		404

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	7.5	Oral	1
Rat	40	Oral	1
Monkey	3	Oral	1

Ethion

Ethion is an organophosphate insecticide and acaricide used to control aphids, mites, scales, thrips, leafhoppers, maggots, and foliar feeding larvae on a wide variety of food, fiber, and ornamental crops. The 3 million lbs produced in 1971 were applied as 25 percent wettable powder, 2-4 percent dust, emulsifiable concentrates, 5 percent granules, oil solution, or in combination with other materials.

Ethion is a colorless liquid soluble to 1 ppm in water. It is likely to be degradable under similar conditions as other organophosphates. When spilled, it will sink and become associated with bottom sediments.

Ethion is toxic to aquatic life. The 96 hour LC_{50} values for bluegill, fathead minnows, and guppy are 0.13 ppm, 2.4 ppm, and 0.13 ppm respectively.[111] Fish food organisms are affected at much lower levels. The 48 hour LC_{50} values for Daphnia magna, Gammarus lacustris, and P. californica are 0.00001 ppm, 0.0012 ppm, and 0.014 ppm respectively.[11] Toxicity does not appear to vary with water quality.[111]

Ethion is a cholinesterase inhibitor like other organophosphates. The oral LD_{50} for rats is 96 mg/kg body weight.[11]

ETHION

SYNONYMS - O,O,O,O-Tetraethyl S,S-Methylene Bisphosphorodithioate,
Ethodan, [illegible]

PRODUCTION QUANTITY - 3,000,000 lbs - 1971

M.P. 12°C

Sp. G. = 1.215

SOLUBILITY - 1 ppm @ 20-25°C

PERSISTENCE

Oxygen Demand - Degradable

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Param	Cond.	Ref.
0.230	48	Bluegill	LC_{50}		22
0.7	24	Harlequin Fish	LC_{10}		22
0.0056	24	Gammarus Lacustris	LC_{50}		22
0.024	24	P. Californica	LC_{50}		22
0.00001	48	Daphnia Magna	LC_{50}		22
0.0032	48	Gammarus Lacustris	LC_{50}		22
0.014	48	P. Californica	LC_{50}		22
2.4	96	Fathead Minnow	LC_{50}		402
0.13	96	Bluegill	LC_{50}		402
0.13	96	Guppy	LC_{50}		402

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	96	Oral	22
Rat	13	Oral	56

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Chickens	400	Oral-Leg Weakness	22

ETHYLBENZENE

Ethylbenzene is used in the production of dyes and other organic compounds. The 8 billion lbs produced in 1971 (198) were shipped in glass bottles, cans, drums, tank cars, tank trucks, and barges.

Ethylbenzene is practically insoluble in water. When spilled, it will form a colorless slick on the surface with small amounts diffusing into the water very slowly. The dissolved portion is subject to slow biodegradation. Quiescent conditions yield usage of only 2.8 percent of the theoretical oxygen demand in 5 days (5). Acclimation accelerates this considerably. In a spill situation, however, no oxygen defficiencies are likely to develop.

A series of tests on various fish reveal a 96 hr TLm range of 29-78 ppm (37). Bluegill appear to be more sensitive than the minnows, guppy, and goldfish tested. A concentration of .25 ppm can affect the taste of fish flesh (4). The slick itself poses a threat to waterfowl and marine mammals.

Ethylbenzene can be moderately toxic via all routes of administration including skin absorption. The lethal level to mice in air is 10,400 ppm (8). A TLV of 435 mg/m^3 has been established. Vapors will be evident above the slick and will cause eye irritation at the .1 percent level. A concentration of 1 percent has been fatal to guinea pigs (38). The oral LD$_{50}$ to rats is reported as 3500 mg/kg body weight. (76)

NAME Ethylbenzene

PRODUCTION QUANTITY 5 billion 1971 (198)

COMMON SHIP OR CONTAINER SIZE Glass bottles, cans, drums, tank cars, tank trucks, barges

USCG Grade C flammable liquid

M.P. -80. °C

B.P. 136. °C

Sp.G. 0.858

SOLUBILITY 14 mg/l at 15°C

PERSISTENCE

Oxygen Demand

BOD_{35} = 8.2 % Theo. using treatmen plant activated sludge-(5)
BOD_5 = 27% Theo. using phenol acclimated activated sludge-(13)
BOD_5 = 2.8% Theo. using quiescent activated sludge-(5)
BOD_5 = 25.2% Theo. using aniline acclimated treatment plant activated sludge-(5)
COD = .89 lb/lb-(64)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
40	96	Bluntnose Minnow	TLm	Const. Temp.	17
29	96	Bluegill	TLm	Const. Temp	17
73	96	Goldfish	TLm	Const. Temp	17
78	96	Guppy	TLm	Const. Temp	17

Mammalian Toxicity

Species	mg/kg b. W.	Administration Route	Ref.
Rat	3500	Oral	96

Ethylenediamine

Ethylenediamine, or diaminoethane, is used as a solvent, emulsifier, textile lubricant, antifreeze agent, and rubber producing reagent. The 62.1 million pounds producted in 1970 (198) were shipped in carbon steel drums, tank cars, and tank trucks. Production increased.

Ethylenediamine is miscible with water, giving a strongly alkaline reaction when dissolved. This is believed to result from dissociation of amine groups to form ammonium ions. In strong alkaline solutions free ammonia gas may be released. The dissolved amine is readily biodegradable. Up to 75 percent of the theoretical oxygen demand is utilized in the first 5 days with an additional 5 percent available in the next 5 days (98).

Ethylenediamine is toxic to fish and fish food organisms. The critical range for chub is reported as 30-60 ppm (1). Fish food organisms are sensitive to 8-30 ppm (1). The solution pH and buffer capacity will be critical in determining resulting toxicity because of the potential for ammonia formation. In saltwater, the 24 hour TLm to brine shrimp is 14 ppm (425).

Ethylenediamine is toxic via all routes of administration including skin absorption. The oral LD_{50} for rats is reported as 1160 mg/kg body weight (8). Water should contain more than 400 ppm if prolonged body contact is anticipated (7). A TLV of 25 mg/m^3 has been established for ethylenediamine vapors in air. The vapors can be quite irritating to skin and eyes.

NAME **Ethylenediamine**

PRODUCTION QUANTITY 62.1 million lbs 1970 (198)

SYNONYMS 1,2-Diaminoethane

COMMON SHIP OR CONTAINER SIZE Carbon Steel drums, tank cars, tank trucks

USCG Grade D combustible liquid

M.P. 8.5 °C

B.P. 116. °C

Sp.G. 0.898

SOLUBILITY Miscible

PERSISTENCE

Oxygen Demand

BOD_5 = 75% Theo.-(98)
BOD_{10} = 80% Theo.-(98)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
30-60	24	Chub	Critical Range	Aerated 15-21°C	1
8	48	Daphnia	Toxic	23°C	1
20		Scenedesmus	Toxic		1
400		E. Coli	Adverse Response		1
30		Microregma	Adverse Response		1
<100	72	Shiners	No Toxic Effect	50°F, Huron	426

Saltwater Toxicity

ppm	hrs	species	parm	cond	ref
14	24	Brine Shrimp	TLm		425

Mammalian

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1160	Oral	8
Rat	1200	Oral	4

ETHYLENEDIAMINETETRAACETIC ACID

Ethylenediaminetetraacetic acid, or EDTA, is employed in chemical production as a chelating agent. Approximately 1.53 million lbs were produced in 1965 (198).

EDTA is only slightly soluble in water. When spilled, the crystalline solid is likely to sink and dissolve at a very slow rate. The dissolved acid is a sequestering agent capable of solubilizing heavy metals and other cations. Hence, the EDTA will introduce additional toxic agents to the water from otherwise insoluble mineral deposits. The dissolved acid is also biodegradable, but the rate is very low. Only .01 lb of oxygen is utilized per lb of acid in 5 days (11). This is not sufficient to cause an oxygen slump in a spill situation.

Work with catfish has detailed a critical range of 100-316 ppm in tap water (1). The ability to solubilize other toxic agents, however, suggests that potentially lower toxic concentrations exist due to the combined effect of the EDTA and the sequestered metal.

EDTA is considered toxic when ingested or inhaled. An oral LD50 of 30 mg/Kg body weight is reported for mice (8). The same value for the calcium salt fed to rats, is 10,000 mg/Kg (113). This suggests that the toxicity of the acid is due at least in part to its ability to tie up cations. When administered in a stable salt form, the reactivity is greatly reduced. Daily intravenous doses of 220 mg/Kg to cattle for 5 days cause mildly toxic reactions (114). A two year chronic feed study using 250 mg/Kg in rats and a one year study with the same dose to dogs revealed no toxic effects at these levels (113). Tests for mutagenic and teratogenic properties have been negative (113).

NAME Ethylenediaminetetraacetic Acid

PRODUCTION QUANTITY 1.53 million lbs 1965 (198)

SYNONYMS EDTA, Edetic Acid, (Ethylene-Dinitrilo) Tetraacetic Acid

M.P. 220. °C Decomposes

SOLUBILITY 500 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = .01 lb/lb using sewage (11)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
167	24	Fingerling Catfish	TLm	U of Okla. Tap	1
133	48	Fingerling Catfish	TLm	U of Okla. Tap	1
129	96	Fingerling Catfish	TLm	U of Okla. Tap	1
100		Fingerling Catfish	All Survive	U of Okla. Tap	1
316		Fingerling Catfish	All Die	U of Okla. Tap	1
750	96	Fathead Minnow	100% Kill	50°F, Huron	426
300	96	Fathead Minnow	Potential Kill	50°F, Huron	426
200	96	Fathead Minnow	No Toxic	50°F, Huron	426

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	20	Oral	18
Rat	10,000	Oral, Calcium Salt	113
Rat	104	Oral	437

FLUORIDES

Fluorides are inorganic salts used in a variety of industries such as pulp and paper production, glass production, uranium fuel fabrication, and pesticide manufacture. They are generally soluble and will dissociate upon contact with water. The fluoride ion in turn will precipitate as calcium fluoride or may become associated with other particulate matter. Fluoride salts are toxic to fish at concentrations as low as 2.3 ppm. The reported range for fish food organisms is 95-270 ppm (1). In general, fluoride concentrations should not exceed 1.5 ppm for fresh or saltwater fish (41). Reduced temperatures appear to increase the level at which toxic reactions occur while hardness lengthens the resistance time for fish (1). Acidity will also by of major importance. Reduction of solution pH below 5.0 will cause massive kills.

In saltwater, Hemens and Warwick report 100 ppm fluorides safe to fish for acute exposure, but 7.2 ppm toxic to brown mussels (119). Fluorine is concentrated by aquatic animals (119).

Fluorides are toxic by ingestion or inhalation. A TLV of 2.5 mg/m^3 has been established. Ingestion of 4 gm of hydrogen fluoride can be hazardous (7). Fluorides in water can also be harmful. Drinking water limits have been set at 1.7 ppm (49). Water with 180 ppm has distinct toxic effects, while a concentration of 2000 ppm is lethal. A fatal dose of 500 mg/kg body weight fluoride has been reported (1). Rabbits have died from 200 mg/kg fluoride fluoride while water with 1 ppm fluoride was toxic to sheep (1).

Aquatic concentrations of interest include a general farmstead use limit of 1 ppm fluoride (1), an aquatic plant limit of 1.5 ppm fluoride (1), and an irrigation water limit for vegetables of 5 ppm (41). Sodium fluoride can be tasted in water at 2.4 ppm (1).

ALUMINUM FLUORIDE

Aluminum fluoride is used largely in metallurgy and ceramics. Some 115,836,000 lbs were produced in 1971 (109).

Aluminum fluoride forms a slightly acidic solution when dissolved. The aluminum cation is readily precipitated with basic reagents under normal conditions. However, sodium fluoaluminate, Na_3AlF_6, is a highly soluble complex which can be formed in the presence of excess fluoride. Calcium is the preferred reagent for precipitation of fluoride. Natural calcium in receiving waters may well reduce fluoride levels below the anticipated stoichiometric concentration.

While no data exists on the aquatic toxicity of the compound aluminum fluoride, its solubility suggests the importance of the toxicity of the individual ionic species. The USPHS recommends permissible drinking water concentrations of .1 mg/l Al^{+3} and 1.2 mg/l F^- (40). Recommended levels of 1.0 and 1.5 ppm F^- are suggested for livestock and aquatic plants respectively (1), while 1 ppm Al^{+3} is recommended as a threshold for irrigable plants (40). The fluoride ion threshold concentration for fresh and salt water fishes is listed at 1.5 ppm (41,42). Vegetables exhibit a chronic threshold for exposure to fluoride ions in irrigation water of 5.0 ppm (40). The low oral lethal dose in guinea pigs is 600 mg/kg body weight (86).

NAME Aluminum Fluoride

PRODUCTION QUANTITY 315,836,000 lbs 1971 (199)

SYNONYMS Aluminum Trifluoride

M.P. 1040. °C

B.P. 1537. °C

Sp.G. 3.07

SOLUBILITY 559,000 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

Toxicity will stem from the fluoride ion.

Salt Water Toxicity

Toxicity will stem from the fluoride ion.

Mammalian

species	mg/kg B.W.	administration route	ref
Guinea Pig	600	Oral - low lethal dose	98

AMMONIUM BIFLUORIDE

SYNONYM - Acid Ammonium Fluoride, Ammonium Hydrogen Fluoride

LARGEST SHIP OR CONTAINER SIZE - Shipped in plastic, rubber, wood, or paraffined drums

M.P. 124.6 C

B.P. - Sublimes

Sp. G. - 1.503

SOLUBILITY - Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Forms hydrofluoride acid in water. Fluoride may be precipitated by calcium.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond	Ref
100	48	Tinca Vulgaris	Lethal		1

AMMONIUM FLUORIDE

SYNONYMS - Neutral Ammonium Fluoride

COMMON SHIP OR CONTAINER SIZE - 1-lb waxed bottles, 250 lb barrels

M.P. - Sublimes

Sp. G. - 1.315

SOLUBILITY - 410,000

PERSISTENCE

Chemical Hydrolysis - Decomposed by hot water into NH_3 and ammonium bifluoride.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Term	Cond	Ref
200	<48	Tinca Vulgaris	death	--	1

Mammalian

Species	mg/kg B. W.	Administration Route	Ref
Rat	31	Intraperitoneal	98
Guinea Pig	150 (low lethal dose)	Oral	98
Guinea Pig	200 (low lethal dose)	Subcutaneous	98

HYDROFLUORIC ACID

Hydrofluoric acid is used in metal trades, glass polishing, and chemical production. The 469,316,000 lbs produced in 1971 (190) were shipped in lead carboys, wax or polyethylene bottles, steel cylinders, and tank barges.

Hydrofluoric acid is a clear, colorless, fuming liquid or gas often shipped in solution. It is freely soluble in water and will be dissolved immediately after spillage. Dilution and natural buffer capacity will neutralize hydrofluoric acid to soluble fluoride salts. A prevalence of calcium ions can lead to precipitation of calcium fluoride with neutralization.

Hydrofluoric acid has been found to be harmful to fish at a concentration of 40 ppm, and lethal at 60 ppm (1). Fluoride salts are toxic to fish at concentrations as low as 2.3 ppm. The reported range for fish food organisms is 95-270 ppm (1). In general, fluoride concentrations should not exceed 1.5 ppm for fresh or saltwater fish (41). Reduced temperatures appear to increase the level at which toxic reactions occur while hardness lengthens the resistance time for fish (1). Acidity will also be of major importance. Reduction of solution pH below 5.0 will cause massive kills.

In salt water, Hemens and Warwick report 100 ppm fluorides safe to fish for acute exposure, but 7.2 ppm toxic to brown mussels (118). Fluorine is concentrated by aquatic animals (118).

Hydrogen fluoride is an inhalative toxin. The LC50 in air for rats is 1310 ppm (124). Subsequently a TLV of 2 mg/m^3 has been established. Ingestion of 4 gm of hydrogen fluoride can be hazardous (7). Fluorides in water can also be harmful. Drinking water limits have been set at 1.7 ppm (49). Water with 100 ppm has distinct toxic effects, while a concentration of 2000 ppm is lethal. A fatal dose of 500 mg/kg body weight fluoride has been reported (1). Rabbits have died from 200 mg/kg fluoride while water with 1 ppm fluoride was toxic to sheep (1).

Aquatic concentrations of interest include a general farmstead use limit of 1 ppm fluoride (1), an aquatic plant limit of 1.5 ppm fluoride (1), and an irrigation water limit for vegetables of 5 ppm (41). Sodium fluoride can be tasted in water at 2.4 ppm (1).

NAME Hydrofluoric Acid

PRODUCTION QUANTITY 460,316,000 lbs 1971 (190)

SYNONYMS Hydrogen Fluoride, Fluorhydric Acid

COMMON SHIP OR CONTAINER SIZE Lead carboys, wax or polyethylene
bottles, steel cylinders, tank barges

DOT Anhydrous- Corrosive liquid; White label; 10 pts outside container
Liquid- Corrosive liquid; White label; 110 lbs outside container

USCG Corrosive liquid, white label

M.P. -83.1 °C

B.P. 19.4 °C

Sp.G. .0009 as gas

SOLUBILITY Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc.

Calcium fluoride is insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	type	cond	ref
Hydrofluoric Acid					
60		Fish	Lethal		1
40		Fish	Harmful		1
Fluorides					
2.3-7.3		Trout	TLm	13°C;Soft	1
2.7-4.7		Trout	TLm	13°C;Soft	1
2.7-5.7		Trout	TLm	Soft	1
2.6-5.1		Trout	TLm	7.5°C,Soft	1
64	240	Trout	TLm		1
75		Carp	TLm		1
100	96	Goldfish	Killed		1
270	96	Mosquito Fish	TLm	Turbid	1
1000	24	Goldfish	Killed	Soft	1
1000	96	Goldfish	Killed	Hard	1

ppm	hrs	species	[illegible]	cond	ref
1.5		Fish	Toxic Unit		119
[illegible]		Rainbow Trout	Toxic	Soft	119
270		Daphnia	Threshold	23°C	1
[illegible]	96	Scenedesmus	Threshold	24°C	1
[illegible]	96	Microregma	Threshold	27°C	1
[illegible]	96	E. Coli	Threshold	27°C	1
1700		Free Living Protozoa Rotifers	Lethal		1

Salt Water Toxicity

Fluorides

100	96	Mullet, Ambassis Gufcho, Therapon Jarbua, Penaeid Prawns	No Effect		119
7.2	108	Brown Mussels	Toxic Effect		119
52	72 days	Mullet, Crab	Physical Deterioration	12% Salinity	119
52	72 days	Shrimp	Affects Reproduction	30% Salinity	119

Mammalian

Species	mg/kg B. W.	Administration Route	Ref.
Guinea Pig	80	Oral	96

Sodium Bifluoride

Sodium bifluoride is a combination salt of sodium fluoride and hydrogen fluoride employed as a sour in laundering, as well as for bleaching leather, disinfecting hides, plating tin, etching glass, and cleaning stone and brick. It is soluble to 33,500 ppm in water raising the acidity and releasing fluoride ion when dissolved. Dilution action will slowly neutralize the acid while the presence of calcium will lead to precipitation of excess fluoride. Aquatic toxicity will result from the released fluoride.

SODIUM BIFLUORIDE

SYNONYMS - Sodium Difluoride, Sodium Hydrogen Fluoride

COMMON SHIP OR CONTAINER SIZE - 100 lb multiwall bags; 125, 175 and 400 lb fiber drums

M.P. - Decomposes

SOLUBILITY - 32,500 @ 20°C

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates on dissolution. Fluoride may precipitate as calcium salt. Acid is neutralized with dilution.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of fluoride ion.

SODIUM FLUORIDE

Sodium fluoride is used to produce insecticides, wood preservatives, enamel, beer, medicinals, paper, and glass. It is also employed in denistry, electroplating, and water fluoridation. Production reached 11,036,000 lbs in 1971 (190).

Sodium fluoride is moderately soluble in water. As a white powder it will sink and dissolve slowly upon spillage. As a solution it will disperse rapidly. The prevalence of of calcium ions in receiving waters will cause formation of the insoluble calcium salt which will precipitate out. The residual precipitate may act as a continuing source of fluoride for an extended period of time.

Sodium fluoride has been found to be harmful to fish and fish food organisms. The Tlm for trout is reported as 2.3-7.6 ppm while that for carp falls in the range 75-91 mg/l (1). Fluoride salts are toxic to fish eggs at concentrations as low as 1.5 ppm. The reported range for fish food organisms is 65-270 ppm (1). In general, fluoride concentrations should not exceed 1.5 ppm for fresh or saltwater fish (41). Reduced temperatures appear to increase the level at which toxic reactions occur while hardness lengthens the resistance time for fish (1). Acidity is of major importance.

In salt water, Hemens and Warwick report acute exposure of 100 ppm fluorides safe to fish but 7.2 ppm toxic to brown mussels (118). Fluorine is concentrated by aquatic animals (119).

Sodium fluoride is an inhalative and ingestive toxin. A TLV of 2.5 mg/m^3 as dust in air has been established. Ingestion of 4 gm of sodium fluoride has been lethal, while 25-45 mg can cause severe symptoms (8). Fluorides in water can also be harmful, with drinking water limits set at 1.7 ppm (49). Water with 100 ppm has distinct toxic effects, while a concentration of 2000 ppm is lethal. A fatal dose of 500 mg/Kg body weight fluoride has been reported (1). Rabbits have died from 200 mg/Kg fluoride while water with 1 ppm fluoride was toxic to sheep (1). The oral LD50 for hamsters is reported to be 70-80 mg/Kg body weight (1).

Aquatic concentrations of interest include a general farmstead use limit of 1 ppm fluoride (1), an aquatic plant limit of 1.5 ppm fluoride (1), and an irrigation water limit for vegetables of 5 ppm (41). Sodium fluoride can be tasted in water at 2.4 ppm (1).

NAME Sodium Fluoride

PRODUCTION QUANTITY 11,026,000 lb 1971 (199)

SYNONYMS Villiaumite

M.P. 993. °C

B.P. 1704. °C

Sp.G. 2.78

SOLUBILITY 43,000 mg/l at 25°C

PERSISTENCE

Chemical Hydrolysis, etc.

Calcium fluoride is insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
270	48	Daphnia Magna	Threshold	Temp. 23C	1
95	96	Scenedesmus	Threshold	Temp 24C	1
225	96	Microregma	Threshold	Temp 24C	1
180	96	E. Coli	Threshold	Temp 27C	1
1700		Protozoa Rotifers	Killed		1
1000	12-29	Goldfish	Survival Time	Very Soft	109
1000	60-100	Goldfish	Survival Time	Hard	109
1000	60-102	Goldfish	Lethal	Hard	144
1000	19-29	Goldfish	Lethal	Very Soft H_2O	144

As Fluorides

ppm	hrs	species	parm	cond	ref
1.5		Eggs	Slower & Poorer Hatching		1
2.3-7.3		Trout	TLm a 18°C	Soft Water	1(NaF)

ppm	hrs	species	[illegible]	cond	ref
2.6-6.0		Trout	Tlm at 13°C	Soft Water	1(NaF)
2.7-4.7		Trout	Tlm		1 (NaF)
5.0-7.5		Trout	Tlm	7.5°C in Soft Water	1(NaF)
7.7	1	Minnows	Not Harmed		1
75-91		Carp	Tlm		1(NaF)
100	98	Goldfish	Survived		1
120	98	Goldfish	Killed		1
250		Rainbow Trout	Toxic	Soft Water	1(NaF)
419	96	Mosquito-Fish	Tlm	Turbid Water	1(NaF)
670		Tinca Vulgaris	Lethal Dose		1(NaF)
1000	21	Goldfish	Killed	Soft Water	1
1000	60	Goldfish	Killed	Hard Water	1

Salt Water Toxicity

.9-4.5		Lobster	Not Toxic		1
>300	48	Shrimp	LC50	Aerated	2
100	96	Mullet, Ambassis, Safgha, Theragon Jarbua, Penaeid Prawns	No Effect		119
7.2	108	Brown Mussels	Toxic Effect		119
52	72 days	Mullet, Crab	Physical Deterioration	20% Salinity	119
52	72 days	Shrimp	Affects Reproduction	20% Salinity	119

Mammalian

species	mg/kg B. W.	administration route	ref
Hamster	70-80	Oral	1
Hamster	76	Oral - Low Lethal Dose	96

STANNOUS FLUORIDE

SYNONYMS- Tin fluoride; Tin difluoride; Fluoristan

M.P.- 210-214 degrees C

SOLUBILITY- Slightly soluble in water

TOXICOLOGY

Fresh Water Toxicity- Toxicity will be that for fluoride and tin (II) ion.

FORMALDEHYDE

Formaldehyde is a colorless flammable gas which is of major importance in commerce. Nearly 4.4 billion lbs. were produced in 1971 (109) for use in manufacture of resins, dyes, textiles, mirrors, explosives, medicines, fungicides, and photographic reagents. Formaldehyde is shipped in drums, carboys, tank trucks, and cars, both as a gas and more commonly as a 37 percent liquid solution (formalin).

When spilled, gaseous formaldehyde will oxidize in air to formic acid. With intimate water contact a considerable amount will dissolve rapidly. Formalin solutions will also be quickly assimilated in the water column. Once dissolved, formaldehyde is quite biodegradable. As much as .8-1.06 lbs. of oxygen per lb. of formaldehyde will be consumed in the first five days. (11) Oxygen deficiencies, however, are not likely to occur since 740 ppm can inhibit sewage organisms to 50 percent.

Formaldehyde is fairly toxic to aquatic species. Ten ppm had no effect on rainbow trout after 72 hours, while the critical level was found to be less than 31.0 ppm. (1) Fifty ppm for 24 hours was lethal to trout (1), and all largemouth bass were killed after 72 hours at 100 ppm concentration. (224) Fish food organisms are affected in the .3-8 ppm concentration range. (1) The compound is apparently less toxic in salt water. An LC_{50} for shrimp after 48 hours was set at 330-1000 ppm, and for flounder, 100-330 ppm. (3)

Formaldehyde is highly toxic when ingested or inhaled. (38) The oral LD_{50} for rats is reported to be 800 mg/kg. (1) The lethal concentration in air for rats is 250 ppm. (8) To humans, it has a pungent suffocating odor which is highly irritating to mucous membranes. (8) Prolonged exposure should be less than 5 ppm. Formaldehyde is a strong irritant and allergen. Carcinogenic effects have been observed in rats after prolonged subcutaneous administration of formaldehyde. (18) The compound has also been implicated in mutagenic changes in mice when given intraperitoneally, the effect being a slight increase in recessive lethals. (18) Formaldehyde is also capable of enhancing the mutagenic effects of X-rays.

The odor threshold for formaldehyde falls in the range 0.8-102 ppm (5b) while the tastes occur at 50 ppm. (4)

NAME Formaldehyde

PRODUCTION QUANTITY 4.4 billion lbs. - 1971

SYNONYMS Methanal, Methyl Aldehyde

COMMON SHIP OR CONTAINER SIZE Bottles, carboys 5-13 gal. drums, tank trucks, tank cars, barges

USCG Grade D or E liquid, depends on concentration

M.P. -92 °C

B.P. -21 °C

Sp.G. 0.815 as liquid

SOLUBILITY Freely Soluble

PERSISTENCE

Oxygen Demand

BOD [illegible] = [illegible] Theo. with methanol acclimated activated sludge - (8)
[illegible] = [illegible] lb/lb using sewage seed - ([illegible])
[illegible] = [illegible] Theo. with pure bacterial culture - (8)
[illegible] = [illegible] Theo. with quiescent activated sludge - (8)
[illegible] = [illegible] Theo. with quiescent activated sludge - (8)
[illegible] = [illegible] Theo. with treatment plant activated sludge - (8)
COD = 1.06 lb/lb - (4)

ECOLOGICAL

Fresh Water Toxicity

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Trout	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	Lethal	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	-	[illegible]
[illegible]	-	Young Salmon	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] °C	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] °C	[illegible]
[illegible]		[illegible]	[illegible]	-	[illegible]
[illegible]		[illegible]	[illegible]	27 °C	[illegible]
		[illegible]			
[illegible]	[illegible]	Channel Cat	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
[illegible]	[illegible]	[illegible]	Lethal	-	[illegible]
[illegible]	[illegible]	[illegible]	Lethal	Formalin	[illegible]
		Punctatus			

ppm	hrs	species	[illegible]	[illegible]	ref
67	25	Channel Catfish Fingerlings	Lethal	Formalin	223
63	24	[illegible]	Lethal	Formalin	224
[illegible]	[illegible]	S. [illegible]	Lethal	Formalin	224
[illegible]	[illegible]	Bufo sp.	Lethal	Formalin	223
67	24	Notemigonus Crysoleucas	Lethal	Formalin	224
70	75	Cyprinus Carpio	Lethal	Formalin	224
>70	24	Ictalurus Melas	Lethal	Formalin	224
100	75	Largemouth Bass	Lethal	Formalin	224
>100	48	Bluegill	Lethal	Formalin	223
[illegible]	75	L. Cyanellus	Lethal	Formalin	223
100	75	Tilapia sp.	Lethal	Formalin	224

Salt Water Toxicity

ppm	hrs	species	[illegible]	[illegible]	ref
[illegible]	48	Shrimp	LC_{50}	Aerated	1
[illegible]	48	Flounder	LC_{50}	Aerated	1

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	800	Oral	1

FORMIC ACID

Formic acid is used as a decalcifying agent, a tanning compound, a rubber reprocessing chemical, a dye reducing agent, and a medicinal. The 43,000,000 lbs produced in 1971 (100) were shipped in stainless steel drums and glass carboys.

Formic acid is a strong reducing agent which is miscible in water. Dilution and natural buffering action will cause neutralization to the soluble sodium and calcium salts. The dissolved formate is subject to biodegradation. Up to .27 lbs of oxygen per lb of acid can be utilized in the first 5 days (6). Acclimation accelerates this usage (13), but the rates are not considered sufficient to cause oxygen slumps in a spill situation. High concentrations retard biological action. A concentration of 800 mg/l causes a 50 percent inhibition of sewage organisms (1).

Formic acid itself is quite toxic to fish and fish food organisms. The 24 hr TLm for bluegill is reported as 175 ppm (15). Aquatic invertebrates are affected in the range 100-175 ppm (1). The algae, chlorella pyrenoidosa, is damaged by a concentration of 200 ppm (6). The formate salt, however, is not considered toxic. The threshold for immobilization of daphnia is 4700 ppm sodium formate (1). This level is believed to depend upon the change in osmotic pressure, and not on acute toxicity. Solution pH and buffer capacity are critical parameters in determining resulting toxicity. In saltwater, the 24 hour TLm for brine shrimp is 410 ppm (126) while Portmann (433) reports a 48 hour LC_{50} to shore crabs of 85 ppm.

Formic acid is highly toxic when ingested or inhaled. The oral LD_{50} for dogs is reported as 4000 mg/kg body weight (1). The intravenous LD_{50} for rabbits is 239 mg/kg (8). Once again, the salts are not as toxic. Administration of 20,000 and 40,000 ppm calcium formate in drinking water for 30 days had no effect on the growth of guinea pigs (1).

NAME Formic Acid

PRODUCTION QUANTITY 48,000,000 lbs 1971 (100)

SYNONYMS Methanoic Acid

COMMON SHIP OR CONTAINER SIZE Stainless steel drums, glass carboys

DOT Corrosive liquid, White Label, 5 gal. outside container

USCG Grade E combustible liquid

M.P. 8.4 °C

B.P. 100.8 °C

Sp.G. 1.22

SOLUBILITY Miscible

DEGRADATION

Oxygen Demand

BOD [illegible] = [illegible] Theo. with phenol acclimated activated sludge-(13)
BOD5 = [illegible] lb/lb using sewage seed-(4)
BOD [illegible] = [illegible] Theo. in quiescent state-(5)
BOD [illegible] = [illegible] lb/lb-(4,5)
BOD20 = [illegible] lb/lb-(24)

ECOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	effect	temp	ref
Formic Acid					
[illegible]	[illegible]	Daphnia	TLm	23°C	[illegible]
[illegible]	[illegible]	Scenedesmus	TLm	24°C	[illegible]
[illegible]	[illegible]	Bluegill	TLm		6
1000		E. coli	No Effect		[illegible]
Sodium Formate					
4700	48	Daphnia	Threshold for Immobilization	23°C	1
410	[illegible]	Brine Shrimp	TLm		[illegible]
88	48	Shore Crabs	Est. LC_{50} Aerated		[illegible]

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	4000*	Oral	[illegible]
Rabbit	239*	Intravenous	[illegible]

FUMARIC ACID

Fumaric acid, an antioxidant, is used in baking powder, dyes, resins, and in the production of polyhydric alcohols. Approximately 51.3 million lbs were produced in 1970 (198).

Fumaric acid is only slightly soluble in water. When spilled, the crystals will sink and dissolve very slowly. The dissolved acid will be diluted and neutralized by receiving waters until it is present as the soluble calcium and sodium salts. The fumarate anion is biodegradable. As much as .6-.7 lb of oxygen per lb of acid can be utilized in the first five days (11). Phenol acclimation accelerates oxygen usage (13). The kinetics of biodegradation may be sufficient to cause localized oxygen deficiencies in a spill situation.

Fumaric acid is closely related to its optical isomer maleic acid. Maleic anhydride has been found to be toxic to fish at 240 mg/l in turbid water (1). The 48 hr TLm for bluegill is reported as 138 mg/l (1). The safe concentration is estimated as 35 mg/l (1). These toxicity levels should be close to those of fumaric acid. Solution pH and buffer capacity will be important in determining resulting toxicity.

Fumaric acid is a slight ingestive toxicant. The intraperitoneal LD50 for mice is reported as 200 mg/kg body weight (121). Direct contact can lead to mild irritation.

NAME Fumaric Acid

PRODUCTION QUANTITY 53.2 million lbs 1970 (198)

SYNONYMS Trans Butenedioic Acid, Allomaleic Acid, trans 1,2-Ethylenedicarboxylic Acid, Boletic Acid

M.P. 286. °C

B.P. 290. °C

Sp.G. 1.635

SOLUBILITY 7000 mg/l at 17°C

PERSISTENCE

Oxygen Demand

BOD$_{12}$ = 41% Theo. using phenol acclimated activated sludge-(13)
BOD$_5$ = .6-.7 lb/lb using sewage seed-(11)

TOXICOLOGICAL

Fresh Water Toxicity

Maleic Anhydride

ppm	hrs	species	parm	cond	ref
240	24 & 48	Mosquito Fish	TLm	Turbid 21-23°C	1
230	96	Mosquito Fish	TLm	Turbid 21-23°C	1
150	24	Bluegill	TLm	Philadelphia Tap, 20°C	1
138	48	Bluegill	TLm	Philadelphia Tap, 20°C	1
30		Bluegill	Estimated Safe Conc.		1

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	200	Intraperitoneal	131

FURFURAL

Furfural is a widely used solvent in petroleum refining and plastics synthesis, and is often used as an insecticide, germicide, and fungicide. Although specific production quantities are not available, it is estimated that production in 1967 was 150 million lbs. (199) Continued growth is predicted in the near future. Furfural is shipped by rail and truck mostly in 55 gallon drums and tank cars, and is listed by the Coast Guard as a combustible liquid - no label required.

When spilled, furfural will sink and dissolve fairly rapidly. The dissolved portion will degrade quite rapidly, especially if acclimated seed is available. R. Hinger *et al.* found that in properly acclimated river water, up to 25 mg/l will disappear in 5-7 days. (1) The five day BOD has been reported as .28-.77 lbs per lb when sewage seed was employed. (1)

The compound is fairly toxic for fresh water fish, having a 48 TLm for sunfish of 16 ppm and 96 hour TLm for mosquito fish and bluegills of 24 ppm. (1)

Furfural is moderately toxic via all routes of administration. The average oral LD_{50} value for mammals falls in the range 100-199 mg/kg body weight. (15) Ingestion of as little as 60 mg causes persistent headaches. Rats fed 10,000 ppm in drinking water died in 114 days. (15) On the other hand, rats fed 25 mg/kg/day for four months showed no significant effects. (15)

Furfural has a median odor threshold of 0.4 ppm (7) and can be tasted in water at 4 ppm. (4)

NAME Furfural

PRODUCTION QUANTITY 150 million lbs - 1967

SYNONYMS 2-Furaldehyde, Pyromucic Aldehyde, Artificial Oil of Ants,
Furan Carbinol, Fural, Furole, Furfurole

USCG Grade E combustible liquid

M.P. -36.5 °C

B.P. 161.7 °C

Sp.G. 1.16

SOLUBILITY 83,000 mg/l @ 20 °C

PERSISTENCE

Oxygen Demand

BOD_5 = 100% removed in river water as determined by chemical analysis - (10)

BOD_5 = .38-.77 lbs/lb using sewage seed - (11)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
32	24	Sunfish	TLm	20 °C	1
16	48	Sunfish	TLm	"	1
44	24	Sunfish	TLm	23-26 °C, Turbid	1
66	48,96	Sunfish	TLm	23-26 °C, Turbid	1
24	96	Mosquito-fish	TLm	Turbid	13
24	96	Bluegill	TLm	"	15

Mammalian

species	mg/kg B.W.	administration route	ref
Dog	2300	Oral	1
Mouse	425	"	13
Rat	127.7	"	13
Guinea Pig	541.7	"	13
Mammals	100-199	Oral	16

GUTHION

Guthion is an organo-phosphate insecticide used on cotton, fruits, vegetables, and ornamentals. The 4 million lbs produced in 1971 (327) were applied as a wettable powder, emulsion concentrate, and liquid.

Guthion is quit insoluble in water. Wettable forms, however, will disperse through the water column soon after spillage. Like many organo-phosphate pesticides, guthion hydrolyzes at a moderate rate in water. When sprayed on cotton leaves, the half-life of liquid and dust forms is 2-4 days (1).

Guthion is quite toxic to aquatic life forms. The predicted 96 hr TL50 values for rainbow trout, bluegill, and minnows are .014, .022 and .235 ppm, respectively (360). Chinook salmon have an observed 96 hr TLm of .0043 ppm (342). Various fish food organisms have median threshold limits in the range .00013-.002 ppm (333). In salt water, sheepshead minnow and spot display sublethal effects when exposed to .01 ppm for 24 hrs (369,370). Guthion may accumulate rapidly in organisms. The cumulative toxicity index is greater than 16 (168).

Guthion is also quite toxic to mammals. The oral LD50 values for rats and mice have been reported as 11 (320) and 20 (8) mg/kg body weight, respectively. An oral LD50 of 80 mg/kg has also been reported for rats (1). The lethal dose for man is estimated to be 1 mg/kg body weight. Direct human ingestion limits of 2 mg/kg have been reported (346).

Birds do not appear as sensitive to guthion as mammals. Doses of 5000 and 6000 mg/kg body weight are required to produce at least 50 percent mortality in quail and pheasants (1). Waterfowl appear similarly resistant (22). It has been suggested that the chronic feeding limit for waterfowl is 0.75 mg/kg/day (165).

NAME Guthion

SYNONYMS O,O-Dimethyl-S-[4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl]-phosphorodithioate; Gusathion; DBD; Methyl Guthion, Bayer-17147; Azinphos-methyl

PRODUCTION QUANTITY 4 Million lbs - 1971

M.P. 73 °C

Sp. G. 1.44

SOLUBILITY 25°C - 33.0 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
[illegible]	96	Fathead	TLm		1
[illegible]	96	Fathead	TLm		
[illegible]	96	Bluegill	TLm		
[illegible]	96	Bluegill	TLm		
[illegible]	96	Guppy	TLm		
[illegible]		Carp Embryo	80-100% Mortality		[illegible]
[illegible]	24	Rainbow	LC50		[illegible]
[illegible]	48	Rainbow	LC50		[illegible]
[illegible]	96	Rainbow	LC50		[illegible]
[illegible]	96	Catfish	TL50	Predicted	[illegible]
[illegible]	96	Bullhead	TL50	Predicted	[illegible]
[illegible]	96	Goldfish	TL50	Predicted	[illegible]
[illegible]	96	Minnow	TL50	Predicted	[illegible]
[illegible]	96	Carp	TL50	Predicted	[illegible]
[illegible]	96	Sunfish	TL50	Predicted	[illegible]
[illegible]	96	Bluegill	TL50	Predicted	[illegible]
[illegible]	96	Bass	TL50	Predicted	[illegible]
[illegible]	96	Rainbow	TL50	Predicted	[illegible]
[illegible]	96	Brown	TL50	Predicted	[illegible]
[illegible]	96	Coho	TL50	Predicted	[illegible]
[illegible]	96	Perch	TL50	Predicted	[illegible]
[illegible]	[illegible]	Mosquito Fish	[illegible] Lethal	In Anatone	[illegible]
[illegible]	96	Coho	TLm		[illegible]
[illegible]	96	Chinook	TLm		[illegible]
[illegible]	96	Rainbow	TLm		[illegible]
[illegible]	96	Threespine Stickleback	TLm		[illegible]

ppm	hrs	species	[illegible]	[illegible]	ref
1.0	96	Goldfish	TLm	Acetone or Ethanol	372
0.12	96	Guppy	TLm	Acetone or Ethanol	372
.1 lb/acre	24	Mosquito Fish	100% Lethal	Pond	373
.000156	96	Gammarus Lacustris	TLm	Acetone	380
.0008	96	Acroneuria Pacifica	TLm		383
.014	96	Ephemerella Grandis	TLm		383
.00013	96	Gammarus Lacustris	TLm		383
.002	96	Pteronarcys Californica	TLm		383
.0008	96	Acroneuria Pacifica (Naiad)	TLm		387
.0020	96	Pteronarcys Californica (Naiads)	TLm		387

Salt Water Toxicity

.01	24	Sheepshead Minnow	Sublethal Effect		369
.01		Spot	79% Normal Activity	Enzyme	370
.01		Sheepshead Minnow	100 Normal Activity	Enzyme	370

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	90	Oral	1
Mice	20	Oral	6
Rat	20	Oral	369

HEPTACHLOR

Heptachlor is one of the polychlorinated aromatic insecticides. The 6 million lbs produced in 1971 (307) were applied in the dust, granule, and emulsion concentrate forms to cotton, corn and alfalfa.

Heptachlor is insoluble in water. Spills of wettable forms, however, will rapidly spread through the water column. While heptachlor is stable to hydrolysis, it volatilizes readily and is subject to catalytic decomposition in the presence of some inert diluents. In river water, no heptachlor was found two weeks after application (320). Similarly, McGee and Wolf report no detectable levels remaining in soil after 42 days (1). Other studies show residues from 80 lb/acre applications persisted for more than nine years. Heptachlor applied at 100 ppm to sandy loam was detected at 16 ppm after 14 years (22). Temperature and surface contact with the atmosphere will be important factors in determining persistence.

Heptachlor is quite toxic to aquatic life. The 96 hr TLm values for bluegill, fathead minnows, and catfish have been reported as .019, .056, and .178 ppm, respectively (1). The LC50 for rainbow trout is .019 ppm (330. Fish food organisms display a 96 hr LC50 range of .0009-.0050 ppm (104). Daphnia magna are immobilized by .00777 ppm (306). In salt water, shrimp suffer a 48 hr TLm at .03-.7 ppm (330.

Heptachlor can be converted to epoxides which are stored in body fat. Oysters have been shown to contain 176 ppm after a 10 day exposure to .01 ppm. In pond water, bluegills have concentrated heptachlor by a factor of 300 (22).

Heptachlor is highly toxic by all routes of exposure (28). Human ingestion should not exceed .10 mg/Kg body weight (346) and drinking water should not exceed .018 ppm (317). The oral LD50 for rats has been reported as 90 mg/Kg body weight (8). In chronic studies, however, adverse effects were noted at a dose level above .0025 mg/Kg/day (15). Mice fed heptachlor for a two-year period showed significant tumor production (15).

Birds appear more tolerant of heptachlor. The LC50 values for mallard ducks and pheasants have been reported as 450-700 ppm and 250-275 ppm, respectively (22). The oral LD50 limits for waterfowl in general are greater than 2000 mg/Kg (165). Birds of prey have been found to accumulate heptachlor from their food (402).

Heptachlor has phytotoxic properties. A concentration of 1 ppm in soil significantly suppressed the growth of corn. Similar results were obtained with beans. Both species also showed macro and micro nutrient concentration alterations. Some plants such as peanuts and soybeans are capable of concentrating heptachlor from the soil by a factor of 6 (22).

NAME Heptachlor

PRODUCTION QUANTITY 6 million lbs - 1971

SYNONYMS 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene; Heptagran; Drinox; E-3314; Velsicol 104

M.P. 95 °C

B.P. 145 °C

Sp.G. 1.58

SOLUBILITY Insoluble - 0.056 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	test	cond	ref
.019	96	Bluegill	TLm		[illegible]
[illegible]	96	Fathead	TLm		[illegible]
.107	96	Guppy	TLm		[illegible]
[illegible]	96	Catfish	TLm		[illegible]
.230	96	Goldfish	TLm		[illegible]
[illegible]	[illegible]	Trout	[illegible]		[illegible]
[illegible]	96	Guppy	TLm		[illegible]
[illegible]	96	Fathead	TLm		[illegible]
[illegible]	[illegible]	Rainbow	LC50		[illegible]
[illegible]	[illegible]	Bluegill	LC50		[illegible]
[illegible]	[illegible]	D. Pulex	TLm		[illegible]
[illegible]	48	Simocephalus Serrulatus	TLm		[illegible]
[illegible]	[illegible]	P. Carinata	[illegible]	Temp [illegible]	[illegible]
.0011	96	Pteronarcys Californica (Naiads)	LC50	Temp 15.5°C	104
.0009	96	Pteronarcella Badia (Naiads)	LC50	Temp 15.5°C	104
.0029	96	Claassenia Sabulosa (Naiads)	LC50	Temp 15.5°C	104
[illegible]	[illegible]	Rainbow	LC50		[illegible]
[illegible]	[illegible]	Rainbow	LC50		[illegible]
[illegible]	96	Rainbow	LC50		[illegible]
[illegible]		Goldfish	LC50		[illegible]
[illegible]	[illegible]	Rainbow	LC50		[illegible]
1.0	24	(Channel) Catfish	Lethal	Tapwater	[illegible]

[illegible]	[illegible]	species	[illegible]	[illegible]	[illegible]
.00777	[illegible]	D. Magna	Immob.		[illegible]
[illegible]	[illegible]	[illegible]	TLm	In Acetone	[illegible]
[illegible]	[illegible]	[illegible]	TLm	In Acetone	[illegible]
[illegible]	[illegible]	[illegible]	TLm	In Acetone	[illegible]
[illegible]	[illegible]	[illegible] [illegible]	TLm	In Acetone	[illegible]
[illegible]	96	[illegible] [illegible]	TLm	Soft	374
[illegible]	48	[illegible] [illegible]	TLm	Soft	374
.096	96	[illegible] [illegible]	TLm	Soft	374
.0	4	Gammarus Lacustris Lacustris	50% Lethal		[illegible]
[illegible]	[illegible]	Redear Sunfish	TLm	Temp [illegible]	[illegible]
[illegible]	[illegible]	Redear Sunfish	TLm	Temp [illegible]	[illegible]
[illegible]	[illegible]	Redear Sunfish	TLm	Temp [illegible]	[illegible]
[illegible]	[illegible]	Redear Sunfish	TLm	Temp [illegible]	[illegible]
[illegible]	[illegible]	Redear Sunfish	TLm	Temp [illegible]	[illegible]
[illegible] lb/ acre	[illegible]	[illegible] [illegible]	50% Mortality	Pond	[illegible]
[illegible]	[illegible]	Rainbow	LC50		[illegible]
[illegible]	48	Pteronarcys Californica	EC50		[illegible]
.083	48	Baetis Sp.	TLm		[illegible]

Salt Water Toxicity

[illegible]	48	Brown Shrimp	TLm	[illegible]
[illegible]	48	White Shrimp	TLm	[illegible]

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	[illegible]	Oral	[illegible]
Male Rat	[illegible]	Oral	[illegible]
Female Rat	[illegible]	Oral	[illegible]

HYDROCHLORIC ACID

Hydrochloric acid is widely used in commerce for hydrolyzing food starch, as a laboratory reagent, in tin and tantalum refining, as a scale remover and cleaner, and in producing chlorides. The 4 billion lbs produced in 1971[(108)] were shipped in carboys, glass bottles, and rubber-lined tank cars.

Anhydrous hydrochloric acid or hydrogen chloride is readily soluble in water, as are its solutions when spilled, hydrochloric acid will sink to the bottom in a heavy layer and spread horizontally while it dissolves into the water column. Laboratory tests have shown that the heavy sublayer may persist for a short period of time. Hydrochloric acid readily dissociates. From the initial entry, the acid will put downward pressure on solution pH. Natural dilution and buffer capacity will slowly neutralize spills.

Hydrochloric acid is toxic primarily because of its ability to lower pH. Hence, concentration is not indicative of toxic thresholds so much as resulting pH and in particular, the typical limiting pH value 5. Toxic concentrations range from 1-10 ppm in distilled water to 100-160 ppm in hard water. These levels appear to hold for both fish and fish food organisms(1). The average 48 hr LC50 values for marine species fall in the 100-1000 ppm range and reflect the greater buffer capacity of seawater (2).

Hydrochloric acid is a strong irritant. Systemic effects are not known, but the LC50 value to rats for vapors in air is reported as 1000 mg/m^3 (225). Vapors at 35 ppm can cause throat irritation. At 50-100 ppm vapors can be tolerated for 1 hr. Longer exposure may result in lung damage.

Hydrochloric acid has an odor threshold of 1.5 ppm (7) and a taste threshold of 32 ppm in water (1). Surface waters for body contact should have pH values in the range of 6.5-8.3 (226).

NAME Hydrochloric Acid

PRODUCTION QUANTITY 4 billion lbs 1971

SYNONYMS Muriatic Acid, Chlorohydric Acid, Hydrogen Chloride

COMMON SHIP OR CONTAINER SIZE Carboys, glass bottles, rubber lined tank cars

DOT (muriatic) Corrosive Liquid, White Label, 10 pts outside container (solution), Corrosive Liquid, White Label, 10 pts outside container (inhibited)

USCG Corrosive liquid, white label

M.P. -114.3 °C

B.P. -84.8 °C

Sp.G. .0020 as gas - 1.63 as acid

SOLUBILITY 823,000 mg/l at 0 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
3.6	48	Sunfish	Lethal	Distilled	1
3.65	24	Carp, Shiners, Suckers	Lethal		1
4	6	Minnow	MLD	Distilled	1
8	24	Sunfish	Lethal		1
10	24	Trout	MLD		1
60	24	Chub	Lethal		1
100	6	Minnow	MLD	Hard	1
100	4	Goldfish	Killed	Hard	1
282	96	Mosquito Fish	TLm	Turbid	1
62	1-4	Daphnia Magna	Survival Time	Soft Static	109
55	1-4	Daphnia Magna	Survival Time	Soft Static	109
60	4-17	Daphnia Magna	Survival Time	Soft Static	109
56	17-72	Daphnia Magna	20% Survival	Soft Static	105
1000	1/6-1/4	Goldfish	Survival Time		109
178	1-2	Goldfish	Survival Time		109

ppm	hrs	species	[illegible]	cond	ref
0.010	6	Stickleback	Relative Toxicity		110
0.1	6	Goldfish	Relative Toxicity		110
60		Daphnia Magna	Immobilized	Lake Erie [illegible]	110
1000	.16-.25	Goldfish	Survival Time		144
190	1.25-1.5	Goldfish	Survival Time		144
170	1.50-2.25	Goldfish	Survival Time		144
166	4.5-6.5	Goldfish	Survival Time		144
80	1-4	Daphnia Magna	Survival Time	Soft	144
65	1-4	Daphnia Magna	Survival Time	Soft	144
60	4-17	Daphnia Magna	Survival Time	Soft	144
55	17-72	Daphnia Magna	Survival Time	Soft	144

Salt Water Toxicity

100-320	48	Shrimp	LC50	Aerated	2
320-1000	48	Cockle	LC50	Aerated	2
100-330	48	[illegible]	LC50	Aerated	2
100-330	48	Starfish	LC50	Aerated	2

HYDROXYLAMINE

Hydroxylamine is employed to manufacture acrylonitrile and other chemicals. Numerous firms market various hydroxylamine salts which are then shipped in lead lined steel drums.

Hydroxylamine is very soluble in water, yielding an alkaline solution upon dissolving. Under alkaline conditions it rapidly decomposes forming ammonia, nitrogen, and water. The presence of metals can cause the formation of various other by-products. Acids stabilize hydroxylamine and often form dissolved salts.

Corti found that 150 ppm of hydroxylamine in water would cause adverse reactions in rainbow trout within 5-10 minutes, and death within 9-10 min (1). The hydrochloric salt of hydroxylamine is toxic to microcysts aeruginosa at 50 ppm (128). Toxicity will be affected by solution pH, buffer capacity, and mineral content.

Hydroxylamine is moderately toxic when ingested. The oral LD50 for dogs is 200 mg/Kg body weight (85). Various sulfate and chloride salts are reported to have and LD50 of 192-840 mg/Kg body weight for rats and mice (127). Intraperitoneal values for the chloride are somewhat lower: 70-250 mg/Kg body weight (127). Rats fed low levels of the chloride salt for 170 days showed no effect on growth or general condition ; there was, however, increased spleen and decreased thyroid development (127).

Hydroxylamine and its salts have been shown to have bacteriostatic and bactericidal action on a number of microorganisms. Hence, through action on the synthesis of nucleic acids by the microorganisms, hydroxylamine may have mutagenic applications. Tests for teratogenesis have been negative. (15)

NAME Hydroxylamine

SYNONYMS Oxammonium

COMMON SHIP OR CONTAINER SIZE Lead lined steel drums

M.P. 33.05 °C

B.P. 56.5 °C

Sp. G. 1.2

SOLUBILITY Very soluble

PERSISTENCE

Chemical Hydrolysis, etc.

Undergoes rapid decomposition at room temperature when contacted with moist air.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
150	.002	Rainbow Trout	Adverse Reaction	13.5°C	1
150	.1	Rainbow Trout	Turned Over	13.5°C	1
150	.2	Rainbow Trout	Lost Motion	13.5°C	1

Mammalian

species	mg/kg B. W.	administration route	ref
Dog	200	Oral	85
Rat	640	Oral-acid sulfate	127
Rat	545	Oral-sulfate	127
Rat	192	Oral-chloride	127
White Mice	423	Oral-chloride	137
Mice	250	Intraperitoneal-chloride	127
Rats	140	Intraperitoneal-chloride	137
Guinea Pig	70	Intraperitoneal-chloride	127

IRON

Iron is a common metal used largely for the production of steel. It is found in many surface waters as a result of both natural mineral contact and waste discharges (58). Important salts include the ferric and ferrous sulfates, hydroxides, and chlorides.

Many common iron salts are quite soluble in water and will soon disperse through the water column after spillage. Under aerobic conditions ferrous ions quickly oxidize to the ferric form. Natural carbonates and alkalinity then quickly precipitate the insoluble carbonate and hydroxide salts. Hence, high iron concentrations do not persist in well aerated waters. High iron levels are observed in acid mine drainage waters, however, where solution pH has dropped markedly. The precipitates formed quickly agglomerate and settle or sorb onto surfaces.

The action of iron salts on aquatic life have been categorized into three exposure types: 1) iron salts reduce solution pH to toxic levels through precipitation of hydroxides; 2) iron salt precipitates deposit on gill membranes causing irritation and respiratory problems; and 3) heavy hydroxide deposits smother fish eggs (1). Solutions of mixed salts have been found lethal to most fish at 1000 ppm, but Stickleback survived up to 2500 ppm (1). Concentrations of .9 and 1.0 ppm have been sufficient to reduce solution pH to toxic levels for rays, pike, tench, and trout (1). Similarly, 5 ppm iron killed dogfish in three hrs (1). The resulting toxicity depends both on the oxidation state of the iron and the buffer capacity of the receiving water. In salt water 48 hr LC50 values of .33 ppm, 56 ppm, 190 ppm and 100 ppm have been reported for prawns, shrimp, cockles, and crabs respectively (2).

Iron is an essential mineral for life. It is found in most drinking water and foods. Excessive iron, however, can be harmful. The oral LD50 for rats fed ferric chloride has been reported as 900 mg/kg body weight (58). A dose of 180 mg/kg ferrous chloride was sufficient to kill a 2 1/2 year old girl (58). A recommended maximum level for drinking water of 0.3 ppm has been set, but it is predicated on taste and esthetic considerations (1). Iron can be detected in distilled water by taste if present at a level of 3.4 ppm or greater (1). Water for livestock should not exceed 0.3 ppm iron (40).

NAME Iron

SYNONYMS Ferrum

M.P. 1535 °C

B.P. 3000 °C

Sp.G. 7.86

SOLUBILITY Insoluble

PERSISTENCE

Chemical Hydrolysis, Etc.

Carbonates and hydroxides are relatively insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
[illegible]		Carp	Killed	pH 5.5	1
1.0		Pike, Tench, Trout	Death	pH 5-6.7	1
[illegible]	[illegible]	Dogfish	Killed		1
10	[illegible]	Trout	Death		1
[illegible]	96	Striped Bass	TL_{50}		[illegible]

Salt Water Toxicity

ppm	hrs	species	resp	cond	ref
33	48	Prawn	LC_{50}	as $FeCl_3$	[illegible]
33	48	Shrimp	LC_{50}	as $FeCl_3$	[illegible]
100	48	Cockle	LC_{50}	as $FeCl_3$	[illegible]
33-100	48	Crab	LC_{50}	as $FeCl_3$	[illegible]
10	48	Marine Fish	TLm		[illegible]

FERRIC AMMONIUM CITRATE

SYNONYMS = Ammonium Ferric Citrate, Iron Ammonium Citrate

Sp. G. = >1.0

SOLUBILITY = Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc. = Iron precipitates as an hydrous oxide with neutralization. Citrate is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that of iron ion.

FERRIC AMMONIUM OXALATE

M.P. - Loses water of hydration 3 at 100° C
Decomposes at 160-170° C

Sp.G. - 1.78 at 17.5° C

SOLUBILITY - Very soluble in water

TOXICOLOGICAL

FRESHWATER TOXICITY - Toxicity will be that of ammonium ion and iron ion.

FERRIC CHLORIDE

Ferric chloride is used in photofinishing, photoengraving, water treatment, dye production, chemical manufacture, and textile processing. The 150,464,000 lbs produced in 1971 (199) were shipped dry or in solution in bottles, jugs, carboys, kegs, barrels, and tank cars.

Ferric chloride is readily soluble in water forming a red acid solution. Dilution will lead to neutralization and subsequent precipitation of ferric hydroxide. Phosphates can also form insoluble salts with iron. Iron sludges on the bottom may continuously release low levels of iron capable of having toxic effects with chronic exposure.

Numerous studies have been made to assess the toxicity of ferric chloride to aquatic life. Fish are harmed by concentrations as low as 0.6 ppm and can be safe at levels as high as 100 ppm (1). The 96 hour TLm for mosquito fish in turbid water is 74 ppm and for goldfish in hard water, 100 ppm (1). Fish food organisms can be killed at levels between 15-126 ppm (1,59). Several solution parameters appear critical in determining toxicity: hardness, pH, temperature and buffer capacity. Soft water lowered the 96 hr TLm for goldfish from 100 ppm to 10 ppm. Acidity appears to be a key also. Jones suggested that, in fact, the principle effects of ferric chloride are due to its acid properties. A chronic aquatic limit of 130 ppm has been recorded for Daphnia Magna (55).

Ferric chloride is considered a slight ingestive hazard. The oral LD50 for rats is reported as 900 mg/kg body weight, while the intravenous value for rabbits is 7.8 mg/kg (8). Dogs have been fed 200-800 mg with no effect while administration of 890 mg/kg to rabbits was lethal (56). Acute poisoning in humans has been reported at a dose of 100 mg/kg body weight (56).

General concentrations of interest include a drinking water limit of 0.3 ppm iron (1) and a livestock watering limit of 0.3 ppm (40). Chloride concentrations should not exceed 100-350 ppm for irrigation purposes or 1500 ppm for use with livestock (41).

NAME Ferric Chloride

PRODUCTION QUANTITY 100,494,000 lb 1971 (100)

SYNONYMS Flores Martis, Molysite, Iron Trichloride

COMMON SHIP OR CONTAINER SIZE Bottles; jugs, carboys, kegs, drums, barrels; tank cars

M.P. 300. °C

B.P. 315. °C
Sp.G. 2.9

SOLUBILITY >919,000 mg/l at 0°C

PERSISTENCE

Chemical Hydrolysis, etc.

Iron is precipitated by neutral or high pH water and phosphates.

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	RESULT	COND	REF
100		Daphnia Magna	Threshold of Immobilization		1
<10	64	Daphnia Magna	Threshold of Immobilization		1
36		Polycelis Nigra	Toxic Threshold		1
200	24	Vector Snails	Killed		90
36	24	Daphnia Magna	TLm	Lake	99
21	48	Daphnia Magna	TLm	Lake	99
16	96	Daphnia Magna	TLm	Lake	99
0.9		Goldfish	Harmful	Tap	1
1.5	24	Stickleback	Harmful	Tap	1
4.35	72	Goldfish	Harmful	Tap	1
6	20	Goldfish	Harmful	Distilled	1
30	6	Goldfish	Harmful	Tap	1
74	96	Mosquito Fish	TLm	Turbid	1
100	1.3	Goldfish	TLm	Soft	1
600	1.6	Minnow	TLm		1
2700	1	Minnow	TLm		1
5000	1	Minnow	TLm		1
1	120	Stickleback	Safe	Tap	1
6	96	Young Eels	Safe		1
10	96	Goldfish	Safe	Soft	1

ppm	hrs	species	para	cond	ref
100	96.	Goldfish	Safe	Hard	1
270	1.5	Minnows	Safe		1
10		Daphnia Magna	Threshold Conc.	Lake Erie	1
116		Cyclops Vernalis	Threshold Conc.	Lake Erie	1
150		Diaptomus Oregonensis	Threshold Conc.	Lake Erie	1

Saltwater Toxicity

10	48	Prawn	LC_{50}	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Rats	900	Oral	3
Rabbit	7.3	Intravenous	3

FERRIC FLUORIDE

M.P. = Sublimes >1000°C

Sp. G. = 3.87

SOLUBILITY = Very slightly soluble

PERSISTENCE

Chemical Hydrolysis, etc. = Iron precipitates as an hydrous oxide.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity is that of fluoride ion.

Saltwater Toxicity = Toxicity is that of iron ion.

FERRIC NITRATE

M.P. = 47.2

B.P. = Decomposes

Sp. G. = 1.684

SOLUBILITY = Soluble

PERSISTENCE

Chemical Hydrolysis, etc. = Iron will precipitate as hydrous oxide.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for iron ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	3250	Oral	96

FERRIC SULFATE

Ferric sulfate is used in water treatment, chemical production, dyeing, soil treatment, and the development of inks. It is presently produced by six major firms and shipped in bags, glass bottles, and wooden barrels.

Ferric sulfate is a soluble solid which will sink when spilled into water and slowly dissolve. Larger amounts of iron may dissolve more rapidly in acid conditions. Natural phosphates can precipitate dissolved solids at neutral pH levels. As the contaminate plume is diluted, ferric hydroxide will form and precipitate out, reducing the overall iron levels.

Ferric sulfate has been found to kill fish at the .1-.7 mg/l level in distilled water (1). The dissolved iron salt is toxic to fish at concentrations of 133 ppm iron in highly turbid water(1) Iron can be concentrated by many bacteria and marine organisms. Water parameters of importance in determining toxicity include pH, hardness, and buffer capacity. Iron sludges on the bottom may provide continuous discharges of iron at levels which are toxic with chronic exposure.

Ferric sulfate is not considered a toxic material. The subcutaneous LD50 for frogs has been reported as 11,000 mg/Kg body weight (8). Drinking water limits have been set at .3 ppm (1), but these were not established for toxicological reasons. The median taste threshold for iron is 3.4 ppm (1). Water for livestock should not exceed .3 ppm iron (40). The concentration of the sulfate ion should not exceed 200-1000 in irrigation water, or 1000 ppm for livestock water (41).

NAME Ferric Sulfate

SYNONYMS Ferric Persulfate, Ferric Sesquisulfate, Ferric Tersulfate

COMMON SHIP OR CONTAINER SIZE Bags, Glass bottles, wooden barrels

M.P. 480. °C Decomposes

Sp.G. 3.1

SOLUBILITY Soluble - 4,400,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc.

Hydrolyzes to ferric hydroxide with dilution and precipitates out. Phosphates also form insoluble salts.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	envi	ref
0.716	12-24	Shiners, Carp, Suckers	Killed	Distilled Water	1
0.1	24	Certain Fish	Killed	Distilled Water	1
133	24,48,96	Mosquito Fish	TLm	Highly Turbid	1
5	24	Rainbow Trout, Bluegill, Sea Lamprey	No Effect	Lake Huron 12°C	1

Mammalian (Amphibian)

species	mg/kg B. W.	administration route	ref
Frogs (Amphibian)	11,000	Subcutaneous	8

FERROUS AMMONIUM SULFATE

SYNONYMS - Ammonium Ferrous Sulfate, Iron Ammonium Sulfate, Mohr's Salt.

M.P. - Decomposes at 100-110°C

Sp. G. - 1.864

SOLUBILITY - Soluble - 100,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Ferrous ion will oxidize to ferric form and precipitate as hydrous oxide with neutralization.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of iron ion.

Mammalian Toxicity

Species	mg/Kg B. W.	Administration Route	Ref
Rat	1200	Oral	96

FERROUS CHLORIDE

SYNONYMS - Lawrencite, Iron Dichloride, Iron Protochloride

M.P. 670-674°C

B.P. 1023°C

Sp. G. - 1.93

SOLUBILITY - 1,600,000

PERSISTENCE

Chemical Hydrolysis, etc. - Ferrous ion oxidizes to ferric form with precipitation of hydrous oxide.

TOXICOLOGICAL

Freshwater Toxicity -

PPM	Hrs	Species	Parameters	Cond.	Ref.
	64	Daphnia magna	immobilization threshold	Lake Erie	1
1000	10	Goldfish	lethal	hard	1
10	96	Goldfish	not harmful	hard	1
13	50	Young eels	highest tolerated		2

Mammalian Toxicity

Species	mg/Kg B.W.	Administrative Route	Ref.
Rat	984 (tetrahydrate)	Oral	96

FERROUS SULFATE

Ferrous sulfate is a widely used inorganic bluish-green crystal important in photography, medicine and veterinary medicine, dyes, fertilizers, pigments, and water sanitation. Over 3 x 10^8 pounds were produced in 1971 (199) and shipped mostly by rail and truck.

Ferrous sulfate is readily soluble and will dissolve rapidly in water when spilled. In natural waters, the ferrous ions will quickly oxidize to the ferric state and precipitate as the hydroxide. Aeration and sunlight will accelerate this process. Consequently, the concentration of iron will seldom be high in neutral waters. (1) Sulfate levels will be reduced by high natural calcium concentrations.

Ferrous sulfate is toxic to aquatic species. Characteristic values found in the literature indicate that 100 ppm for 24 hours was lethal for minnows, goldfish, and trout, while 6.4 ppm for 24 hours was damaging, but not lethal, for shiners, suckers, and carp. (1) A concentration of 500 ppm killed goldfish in 1.3-5 days. (1) Concentrations found to not be harmful have been anywhere from 5 ppm to 1000 ppm for mature fish after one week. (1) Toxicity depends in part on solution pH, hardness, and dissolved oxygen content.

For salt water species, where the compound had converted to ferric chloride, LD_{50}s after 48 hours exposure were: for prawns, 33 ppm; for shrimps, 56 ppm; for cockles, 100 ppm, and for crabs, 90-100 ppm. (2) Studies with radioactive iron

(58-59) have shown that aquatic species accumulate iron in thousand-fold proportions; for instance, diatoms, 2833-fold; unspecified fish, 10,000-fold; algae, 30,000-fold, and phytoplankton, 291,000-fold. (1) It must be inferred that biomagnification in successive species occurs ascending the food chain.

Ferrous sulfate is not a factor in considering toxicity of water for mammals. Actually, iron is an essential nutrient in trace amounts. Ferrous sulfate has a taste threshold at about 3 mg/l. (1) It has been postulated that a safe concentration of iron in water for domestic use would be 0.3 mg/l and for industrial purposes, 0.1 mg/l. (1) The experimental oral LD_{50} for rats has been reported as 5000 mg/kg body weight. (8) Water for livestock use should not exceed 0.3 ppm iron. (60)

NAME Ferrous Sulfate

PRODUCTION QUANTITY 300,000 lbs. - 1971

SYNONYMS Green Vitriol, Iron Vitriol, Iron Sulfate, Iron Protosulfate, Feosol, Ironate, Presfersul, Irosul, Sulferrous, Copperas

M.P. 64 °C

B.P. 300 °C loses water

Sp.G. 1.899

SOLUBILITY 156,500 mg/l @ 0 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Soon oxidizes to ferric form and precipitates as hydroxide.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	test	cond	ref
3.9	4-24	Shiners, Suckers, Carp	Lethal or Harmful	Distilled	1
6.4	24	Shiners, Suckers, Carp	Lethal or Harmful	-	1
100	24	Minnows, Goldfish, Trout	Lethal or Harmful	-	1
100	4.2-7 Days	Bass	Lethal or Harmful	-	1
-	2.5-3.5 Days	Sunfish	Lethal or Harmful	-	1
133	24	Brook Trout	Lethal or Harmful	-	1
315	3	Minnows	Lethal or Harmful	Distilled	1
500	1.3-5 Days	Goldfish	Lethal or Harmful	-	1
1,000	9-21	Bass	Lethal or Harmful	-	1
1,000	48	Very Young Carp	Lethal or Harmful	-	1
1,000	5-10	Goldfish	Lethal or Harmful	-	1
	2.5-9	Bass	Lethal or Harmful	-	1
1,000	2-16	Goldfish	Lethal or Harmful	Hard	1
1,390	44 Min.	Minnows	Lethal or Harmful	-	1

ppm	hrs	species	parm	cond	ref
8,721	31-66 Min.	Trout, Salmon	Lethal or Harmful	Tap	1
6,950	104 Min.	Minnows	Lethal or Harmful	-	1
10,000	1 Week	Tench	Lethal or Harmful	-	1
10,000	1 Day	Other Fish	Lethal or Harmful	-	1
13,900	60 Min.	Minnows	Lethal or Harmful	-	1
152	-	Daphnia	Theshold for Immo-bilization	Lake Erie	1
5	24	Carp, Shiners, Suckers	Not Harmful	-	1
17.1	1	Minnows	Not Harmful	-	1
50	7 Days	Bass, Blue-gills	Not Harmful	-	1
50	24	Trout	Not Harmful	-	1
-	-	Bass, Sunfish	Not Harmful	-	1
100	96	Goldfish	Not Harmful	Hard	1
-	7 Days	Goldfish	Not Harmful	-	1
100	7 Days	Goldfish	Not Harmful	-	1
100	-	Carp, Tench	Not Harmful	-	1
300	105 Min.	Minnows	Not Harmful	-	1
1,000	Over 1 Week	Mature Fish	Not Harmful	-	1

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
39	48	Prawn	LC_{50}	As $FeCl_3$	2
56	48	Shrimp	LC_{50}	As $FeCl_3$	2
190	48	Cockle	LC_{50}	As $FeCl_3$	2
90-100	48	Crab	LC_{50}	As $FeCl_3$	2

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	5000	Oral	9
Rabbit	59	Intravenous	9

ISOPRENE

Isoprene is employed in the production of butyl rubber. It is commonly associated with rubber latex. Approximately 360 million lbs were produced in 1969(100)

Isoprene is only slightly soluble in water. When spilled, it will form a colorless slick and dissolve very slowly. Isoprene is unstable and easily oxidized. The surface slick should undergo degradation, and possible polymerization. Direct sunlight will accelerate this. Dissolved isoprene should be biodegradable; however, no confirming data are available. Oxygen utilization is not inhibited by 30 mg/l(1).

Isoprene is toxic to fish. The 96 hr Tlm values for fathead minnows, largemouth bass, goldfish and guppies are 75 ppm 10 ppm, 180 ppm, and 140 ppm, respectively (37). The undissolved slick poses a threat to waterfowl and marine mammals.

Isoprene is moderately toxic if inhaled or ingested. The LD50 for mice in air is 144 mg/l (8). Chronic feeding studies indicate that 5 mg/l in drinking water is the threshold limit for warm-blooded animals (1). Rabbits given 2.5 mg/Kg/day for 3 mos display a change in catalase activity while rats fed 0.25 mg/Kg/day suffer a change in conditioned reflexes (15).

The median odor threshold for isoprene is .005 ppm (1).

NAME Isoprene

PRODUCTION QUANTITY 260 million lbs-1969

SYNONYMS 2-Methyl Butadiene, B-Methylbivinyl, Hemiterpene

DOT Flammable Liquid, Red Label, 10 gal in an outside container

USCG Grade A flammable liquid, red label

M.P. -120. °C

B.P. 34. °C

Sp.G. 0.681

SOLUBILITY Slightly soluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
75	96	Fathead Minnow	TLm		17
39	96	Large-Mouth Bass	TLm		17
180	96	Goldfish	TLm		17
140	96	Guppy	TLm		17

KELTHANE

Kelthane, or dicofol, is a polychlorinated aromatic miticide. It is commonly used on fruits and vegetables. The four million lbs of kelthane produced in 1971 (327) were applied as an emulsion concentrate and a wettable powder.

Kelthane is relatively insoluble in water. It will rapidly spread through the water column, however, if spilled in a wettable form. Little is known of the water chemistry of kelthane other than that it hydrolizes under alkaline solutions. Persistence is likely to be high.

Kelthane appears to be more toxic to fish than to aquatic invertebrates. The 24 hr Tlm for mosquito fish has been reported as 1.9 ppm (376), while the 24 hr LC50 for rainbow trout is given as .110 ppm (330). These contrast with a reported 48 hr LC50 of 100 ppm for rainbow trout (22). Similar values for stoneflies and waterfleas have been reported as 3000 ppm and 390 ppm, respectively (22).

The acute oral toxicity of kelthane to rats has been reported as 575-1100 mg/Kg body weight (1). In birds, the LC50 ranges from 1700-1900 ppm for mallard ducks to 2800-3000 ppm for bobwhites (22).

NAME Kelthane

PRODUCTION QUANTITY 4 Million lbs - 1971 (327)

SYNONYMS 4,4'-Dichloro-α-(Trichloromethyl) Benzhydrol; DTMC;
FW 293; Dicofol

M.P. 77 °C

B.P. 225 °C

SOLUBILITY - Insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
0.5	48	Guppies	100% Kill		1
.110	24	Rainbow	LC50		330
1.9	24	Mosquito Fish	Tlm		376
100	48	Rainbow Trout	LC50		22
1000	48	Pteronarcys Californica	LC50		22
390	48	Daphnia Magna	LC50		22

Mammalian

species	mg/Kg B. W.	administration route	ref
Rat	1100	Oral	329
Rat	1000	Oral	329
Rat	700	Oral	22

LEAD

Lead is a common metal often found in mineral form with deposits of other metals. Ground and surface waters used for domestic supplies have been found to contain anywhere from trace amounts to .04 ppm lead (1). The average content is about .01 ppm lead (1). Lead is used in x-ray and nuclear shielding, paints and pigments, alloys, steel, batteries, textile finishing, photography, engraving, and pesticides. Commercially important salts include the acetate, arsenate, chloride, oxide, nitrate, and sulfate. Tetramethyl and tetraethyl lead compounds are also widely distributed.

Many lead salts are soluble and will soon dissolve after spillage. The carbonate and hydroxide, however, are not soluble, and the sulfate is only sparingly so. Hence, lead does not persist at high concentrations in natural waters. Lead may interfere with natural biological activity in receiving waters. Bacterial decomposition of organic matter is inhibited by .1 ppm lead (1).

Lead toxicity to fish appears to result from a reaction between the dissolved lead and a constituent of mucous which produces a film of coagulated matter that soon engulfs the gill membranes and suffocates the fish (1). Lead is extremely toxic in soft water and less so in hard. Reduced dissolved oxygen content also increases lead toxicity. Trout die in 18 hrs when exposed to 1.4 ppm lead in soft water (11).

Minnows display a 96 hr Tlm of 2.4 ppm (1). In hard water bluegill and minnows exhibit a 96 hr Tlm of 65 and 75 ppm, respectively. Fish in general have a threshold concentration of 0.1 ppm lead (41). The threshold for Daphnia magna has been reported as 5 ppm (81). Lead nitrate at 4.1 ppm lead had no effect on the phytosynthetic activity of giant kelp after a four day exposure (1).

Lead is considered highly toxic to mammals when inhaled or ingested. It is not an essential nutrient. Rather, it acts as an accumulative poison. Acute doses of 15 mg/Kg body weight can be fatal (208). The approximate oral LD50 for rats has been reported as 100 mg/Kg (65). Similarly, 400 mg/Kg killed calves within a few days (1). It is believed that lead is excreted from the human body at 0.3-1.0 mg/day (1). Average intake in North America is 0.33 mg/day, of which 3-10 percent is derived from water (1). Drinking water limits have been set at .05 ppm (1). Water for livestock should also not exceed .05 ppm (40). Chronic lead poisoning has been reported in animals given 0.18 mg/l in soft water (56). As little as 0.005 mg/Kg administered to rats on a chronic basis can cause changes in the central nervous system (56).

Lead salts may also be quite toxic to plants. Klintworth claims that any concentration of lead is harmful, but other studies show stimulating effects at 1.5-2.5 mg/l in water (1). A concentration of 50 mg/l lead nitrate can kill oats and potatoes in a week's time (1). Irrigation water in general should not contain more than 15 ppm (42).

NAME Lead Acetate

PRODUCTION QUANTITY 2.4 billion lbs - 1967 - (198)

SYNONYMS Sugar of Lead, Salt of Saturn, Plumbum Acetate

M.P. 75 °C

B.P. 280 °C decomposes

Sp.G. 2.25

SOLUBILITY 433,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydroxide and carbonate are insoluble. Sulfate is sparingly soluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	effect	cond	ref
50	16-283 Days	Catfish	Injury to Blood Cells	Tap	1
0.4	24-48	Minnows	Killed	Distilled	1
10		Trout	Lethal	Stream	1
5	4-16	Minnows	Lethal	Distilled	1
10	12 Days	Goldfish	Lethal	Distilled	1
2.8 as Lead		Fish	Lethal		1
1 as Lead	Long Term	Carp	Heme Serum		1

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	1000-10,000	Oral	17
Rat	150	Intraperitoneal	8
Rat	120	Intravenous	255

NAME Lead Arsenate

PRODUCTION QUANTITY 8 million lbs. - 1971 (199)

DOT Poison B, Poison Label, 200 lbs. in an outside container

USCG Poison B, Poison Label

M.P. 220° C loses water

B.P. 720° C decomposes

SP.G. 7.80

SOLUBILITY Insoluble

PERSISTENCE

Chemical Hydrolysis, etc.

Hydroxide and carbonate are insoluble. Sulfate is sparingly soluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs.	species	parm	cond.	ref.
25	24	Trout	Killed		1
17.1	1	Minnows	No Harm	Stabilized Tap	1
25	24	Trout	Killed		1
0.1		Fish	Toxic		1
0.1		Sticklebacks	Toxic		1
0.1-0.2		Sticklebacks	Toxic	Soft	1
0.2		Fish	Toxic	Soft	1
0.21		Guppy	Toxic		1
0.25		Fish	Toxic	Fresh	1
0.33		Minnows, Brown Trout	Toxic		1
0.34		Coho Salmon Sticklebacks	TLM	1000-3000PPM Dis Solids	1
0.4	26-48	Minnows	Toxic	Dist	1
0.41	24	Coho Salmon	TLM	1000-3000PPM Dis Solids	1
0.53	24	Sticklebacks	TLM	1000-3000PPM Dis Solids	1
.75		Minnows	Toxic		1
1.0	Long term	Carp	Toxic		1
1.0	204	Sticklebacks	Toxic		1
1.4	16-24	Rainbow Trout	Toxic	Soft	1

ppm	hrs.	species	parm	cond.	ref.
1.4	48	Bluegill	TLm	TAP	1
2	24	Bluegill	TLm	TAP	1
2.4	96	Fathead Minnows	TLm	Soft	1
2.7	6-18	Minnows	Toxic	Dist	1
2.8		Fish	Toxic	Fresh	1
4.0	10-17	Rainbow Trout	Toxic	Soft	1
4.0		Fish	Toxic		1
5.5		Trout	Toxic	Stream	1
5.5		Goldfish	Toxic	Dist	1
6.3	24 & 48	Bluegill	TLm		1
10		Goldfish	Toxic		1
17		Goldfish	Toxic		1
27	16-183 days	Catfish	Toxic	TAP	1
40	80	Goldfish	Toxic		1
61	80	Goldfish	Toxic		1
75	96	Fathead Minnows	TLm	Hard	1
0.07		Trout	Safe		1
0.7		Minnows and Sticklebacks	Safe	Soft TAP	1
1.0		Goldfish	Safe	Soft	1
4.0		Plaice Eggs	Safe		1

Mammalian

species	mg/kg B.W.	administration route	ref.
Male Rat	825	Oral	22
Sheep	192	Oral	22
Rabbit	125	Oral	22
Chicken	450	Oral	22
Rat	800	Oral	MERCK
Man	1.4	LD_{LO} Oral	HEW
Rat	100	LD_{50} Oral	HEW

NAME Lead Chloride

SYNONYMS Cotunnite

M.P. 501 °C

B.P. 950 °C

Sp.G. 5.85

SOLUBILITY 9900 mg/l at 20 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydroxide and carbonate insoluble. Sulfate sparingly soluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	type	water	ref
10	5	Daphnia Magna	Survived		1
10	24	Daphnia Magna	Died		1
1.6 as Pb	18-24	Rainbow Trout	Median Survival	Soft	1
4.0 as Pb	10-12	Rainbow Trout	Median Survival	Soft	1
0.01-1.0	240	Daphnia Magna	Toxic		1
0.33		Freshwater Fish	Toxic		1
0.58		Whitefish Fry	Toxic	Lake Erie	1
1.25		Daphnia Magna	Toxic	Lake Erie	1
3.2	96	Fathead Minnow	TLm	Soft	1
10.0	24	Daphnia Magna	Toxic	Distilled	1
>100	96	Fathead Minnow	TLm	Hard	1
138		Cyclops Vernalis	Toxic	Lake Erie	1
5.58	96	Fathead Minnow	TLm	Soft	76
482	96	Fathead Minnow	TLm	Hard	76
23.8	96	Bluegill	TLm	Soft	76
442	96	Bluegill	TLm	Hard	76
31.5	96	Goldfish	TLm	Soft	76
20.6	96	Guppy	TLm	Hard	76

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	1000-10,000	Oral	12
Guinea Pig	2000	Oral	8

LEAD FLUOBORATE

Sp. G. - >1.0

SOLUBILITY - Soluble

PERSISTENCE

Chemical Hydrolysis, etc. Lead will precipitate as the hydroxide, carbonate, and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for lead ion.

Mammalian Toxicity

Species	mg/kg B.W.	Administration Route	Ref.
Rat	50 low lethal dose	Oral	96

LEAD FLUORIDE

M.P. - 855°C

B.P. - 1290°C

Sp. G. - 8.24

SOLUBILITY - 640 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Lead will precipitate as the hydroxide, carbonate, and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for fluoride ion.

Saltwater Toxicity - Toxicity will be that for lead ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Guinea Pig	4000	Oral - Low Lethal Dose	96

LEAD IODIDE

SYNONYMS - Lead Diiodide

M.P. 402°C

B.P. 954°C

Sp. G. - 6.16

SOLUBILITY - 440

PERSISTENCE

Chemical Hydrolysis, etc. Lead will precipitate as the hydroxide, carbonate and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for lead ion.

NAME Lead Nitrate

COMMON SHIP OR CONTAINER SIZE Bottles, cartons, boxes, barrels, casks

DOT Oxidizing material, yellow label, 100 lbs in an outside container

M.P. 470 °C decomposes

Sp.G. 4.53

SOLUBILITY 376,500 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydroxide and carbonate insoluble. Sulfate sparingly soluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	type	cond	ref
1.6		Tadpoles	Harms Growth	Tap Water	1
3.3		Tadpoles	Lethal	Tap Water	1
5.	2	Goldfish	Survived	6.3 mg/l Dissolved O_2	1
5	2	Goldfish	Died	1.6 mg/l Dissolved O_2	1
3	12	Fundulus	Fatal	Fresh Water	1
0.1		Sticklebacks	Lethal Con. Limit		1
1.0	1 Day	Sticklebacks	Average Survival Time		1
0.7	2 Days	Sticklebacks	Average Survival Time		1
0.3	1 Week	Sticklebacks	Average Survival Time		1
63	80	Goldfish	Died		1
1.6(Pb)	18-24	Rainbow	Median Survival	Soft	1
4.0(Pb)	10-12	Rainbow	Median Survival	Soft	1
0.4(Pb)	48	Minnows	Died		1
10(Pb)	96	Fish	No Harm	Hard Water	1
27.5-49	24	Tubificid Worms	TLm		326

ppm	hrs	species	parm	cond	ref
0.10		Stickleback	Toxic	Tap	1
0.63		Minnows, Sticklebacks, and Brown Trout	Toxic	Tap	1
10	2.5	Trout	Toxic	Natural	1
10	24 and 48	Bluegill Sunfish	TLm	Tap	1
10	96	Goldfish	Toxic	Hard	1
16		Goldfish	Toxic	Tap	1
16.8	20	Minnows	Toxic		1
100	80	Goldfish	Toxic	Hard	1
165		Fish	Toxic	Distilled	1
240	96	Mosquito Fish	TLm	Highly Turbid	1
250	96	Goldfish	Toxic	Distilled	1
254	2-3	Minnows	Toxic	Distilled	1
630	3	Minnows	Toxic		1
3330	2.2	Minnows	Toxic		1
6300	1.5	Minnows	Toxic		1
16600	1.4	Minnows	Toxic		1
44090	1	Minnows	Toxic		1
63000	1	Minnows	Toxic		1
5.0	96	Daphnia Magna	Threshold	Havel River 24 °C	1
2.5	96	Scenedesmus	Threshold	Havel River 24 °C	1
1.3	96	E. Coli	Threshold	Havel River 24 °C	1
1.25	96	Microregma	Threshold	Havel River 24 °C	1

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
200		Sea Urchin Eggs	Abnormalities		1
4.1 as Pb		Giant Kelp	No Bad Effect on Photosynthesis		1
375	48	Prawn	LC50	Aerated	2
>500	48	Cockle	LC50	Aerated	2

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	1000-10,000	Oral	12
Rat	400	Intraperitoneal	8
Rat	270	Intraperitoneal	85

LEAD STEARATE

SYNONYMS - Stearic Acid Lead Salt

M. P. 100-115°C

Sp. G. - 1.4

SOLUBILITY - 50

PERSISTENCE

Chemical Hydrolysis etc. Lead can precipitate as hydroxide, carbonate, and sulfate salts. Stearate ion is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for lead ion.

Mammalian Toxicity

Species	mg/Kg B.W.	Administration Route	Ref.
Guinea Pig	20,000 MLD	Oral	8

NAME Lead Sulfate

M.P. 1170 °C

Sp.G. 6.2

SOLUBILITY 425 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydroxide and carbonate are insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
25	96	Goldfish	Killed	Distilled	1
25	2-3	Minnows	Killed	Distilled	1
26		Goldfish	Lethal Con.		1
1.6 as Pb	18-24	Rainbow Trout	Median Survival	Soft	1
4.0 as Pb	10-12	Rainbow Trout	Median Survival	Soft	1

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	1000-10,000	Oral	12
Guinea Pig	300	Intraperitoneal	8

LEAD SULFIDE

SYNONYMS - Galena

M.P. 1114°C

B.P. 1281°C Sublimes

Sp. G. = 7.5

SOLUBILITY = .86

PERSISTENCE

Chemical Hydrolysis, etc. Lead precipitates as hydroxide, carbonate, and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for lead ion.

Mammalian Toxicity

Species	mg/Kg B.W.	Administration Route	Ref.
Rat	1600	Intraperitoneal	8

LEAD TETRAACETATE

M.P.: 175°C

Sp. G.: - 2.228

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. Decomposes in water forming lead dioxide and acetic acid. The dioxide precipitates while acetic acid is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that of lead ion.

LEAD THIOCYANATE

SYNONYMS - Lead Sulfocyanate

Sp. G. - 3.82

SOLUBILITY - 500

PERSISTANCE

Chemical Hydrolysis, etc. Lead will precipitate as hydroxide, carbonate, and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for lead ion.

LEAD THIOSULFATE

SYNONYM - Lead Hyposulfite

M.P. - Decomposes

SpG - 5.18

SOLUBILITY - 300

PERSISTENCE

Chemical Hydrolysis, etc. - Lead is precipitated as hydroxide, carbonate, and sulfate salt. Thiosulfate anion may oxidize to sulfate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for lead ion.

LEAD TUNGSTATE

SYNONYMS - Lead Wolframate, Raspite

M.P. 1130°C

SpG. 8.46

SOLUBILITY = 300

PERSISTENCE

Chemical Hydrolysis, etc. - Lead will precipitate as hydroxide, carbonate and sulfate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that of lead ion.

Lindane

Lindane is an organochlorine insecticide employed for many uses including household applications. It is also widely used in seed treatments. Pure product must not contain less than 99 percent BHC. The <1 million pounds formulated as emulsifiable concentrates, wettable powders, oil-base sprays, dusts and aerosols.

Lindane is soluble to 10 ppm in water. When spilled, it will sink. It has strong vapor properties, and may escape to the atmosphere over time. Some, however, will be associated with sediments. When BHC was applied at 10 lb/acre in soil, it persisted greater than 11 years. At 25 ppm in soil, it persisted two years and 10 percent remained after 14 years when applied at 100 ppm in sandy loam (22).

Lindane is quite toxic to fish. The 96 hour LC_{50} for bluegill ranges from 0.035-0.1 ppm as the temperature is varied from 45-85°F (22). The 96 hour LC_{50} values for fathead minnow, rainbow trout, and coho salmon are 0.087, 0.027, and 0.041 ppm (22). Fish food organisms are also adversely affected at low concentrations. The 48 hour LC_{50} values for Pteronarcys californica, gammarus lacustris, and daphnia pulex are 0.008, 0.088, and 0.46 ppm respectively (22).

In saltwater, the 96 hour LC_{50} for oysters is 1.6-9.1 ppm (23, 411). Sand shrimp and hermit crabs have a 24 hour LC_{50} value of 0.014 and 0.038 ppm respectively (22).

Lindane is and ingestive and inhalation hazard. The oral LD_{50} for rats is reported to be 76 mg/kg body weight (98). Values for other laboratory animals fall in the same range (22). Birds appear more resistant. The oral LD_{50} for young mallards is reported as >2000 mg/kg body weight (22). In man, the dangerous acute dose has been estimated as 7-15 gms (38). A drinking water limit of 0.056 ppm has been established (337). While tests for carcinogenesis were negative, investigations with root tips produced C-mitosis and chromosome observations (15).

LINDANE

SYNONYMS - Gammahexane, Streunex, BHC, GBH, HCCH, HCH, 666, Benzahex, Chemhex, Gamacid, Hexadon, 1,2,3,4,5,6-Hexa chlorocyclohexane, Gamaphex, Gammalin, Gammex, Gammexane, Lindafor, Lindagam, Lintox, Novigam, Silvanol, Benzene Hexachloride

PRODUCTION - <1,000,000 lb/yr - 1971

M.P. = 112.9°C

Sp. G. = 1.87

SOLUBILITY - 10 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Persistent and bioconcentrative.

TOXICOLOGICAL

ppm	hr	Species	Test	Immobile	Ref.
0.23	96	Goldfish	LC_{50}	BHC	22
0.03	24	Rainbow Trout	LC_{50}	BHC	22
.051	48	Bluegill	EC_{50}	24°C	22
.022	48	Rainbow Trout	EC_{50}	13°C	22
0.1	24	Bluegill	LC_{50}	12.7°C	22
0.1	24	Bluegill	LC_{50}	18.3°C	22
0.095	24	Bluegill	LC_{50}	23.8°C	22
0.075	24	Harlequin Fish	LC_{50}		22
0.018	48	Rainbow Trout	LC_{50}		22
0.002	96	Brown Trout	LC_{50}		22
0.027	96	Bluegill	LC_{50}		22
0.032	96	Bluegill	LC_{50}		22
0.041	96	Bluegill	LC_{50}		22
0.044	96	Bluegill	LC_{50}		22
0.064	96	Bluegill	LC_{50}		22
0.068	96	Bluegill	LC_{50}		22
0.068	96	Bluegill	LC_{50}		22
0.083	96	Bluegill	LC_{50}		22
0.087	96	Bluegill	LC_{50}		22

ppm	hr	Species	Parm	Parm	Ref.
0.090	96	Bluegill	LC$_{50}$		22
0.131	96	Bluegill	LC$_{50}$		22
0.16	24	Bluegill	LC$_{50}$	45°F	22
0.1	24	Bluegill	LC$_{50}$	55°F	22
0.1	24	Bluegill	LC$_{50}$	65°F	22
0.1	24	Bluegill	LC$_{50}$	75°F	22
0.036	24	Bluegill	LC$_{50}$	85°F	22
0.088	48	Bluegill	LC$_{50}$	45°F	22
0.075	48	Bluegill	LC$_{50}$	55°F	22
0.076	48	Bluegill	LC$_{50}$	65°F	22
0.053	48	Bluegill	LC$_{50}$	75°F	22
0.027	48	Bluegill	LC$_{50}$	85°F	22
0.065	96	Bluegill	LC$_{50}$	45°F	22
0.053	96	Bluegill	LC$_{50}$	55°F	22
0.056	96	Bluegill	LC$_{50}$	65°F	22
0.038	96	Bluegill	LC$_{50}$	75°F	22
0.025	96	Bluegill	LC$_{50}$	85°F	22
0.012	24	Pteronarcys Californica	LC$_{50}$		22
0.012	24	Gammarus Lacustris			22
0.008	48	P. Californica			22
0.088	48	G. Lacustris			22
0.460	48	Daphnia Pulex			22
0.52	48	Simocephalus Serrulatus	EC$_{50}$	Immobile	22
0.46	48	Daphnia Pulex	EC$_{50}$	Immobile	22
0.52	48	S. Serrulatus	EC$_{50}$		22
0.42	48	Daphnia Pulex	EC$_{50}$		22
0.002	48	P. Californicas	EC$_{50}$		22
14	24	Fowlers Toad Tadpoles	LC$_{50}$	Lindane	22
4.0	24	Chorus Frog Tadpoles	LC$_{50}$	Lindane	22
13	24	Fowlers Toad Tadpoles	LC$_{50}$	BHC	22
1.93	48	Green Sunfish - Resistant	LC$_{50}$		449
0.05	48	Green Sunfish - Susceptible	LC$_{50}$		449

ppm	hr	Species	Parm	Cond.	Ref.
3.14	48	Golden Shiner - Resistant	LC$_{50}$		449
0.15	48	Golden Shiner - Susceptible	LC$_{50}$		449
0.044	96	Channel Catfish	LC$_{50}$		360
0.064	96	Black Bullhead	LC$_{50}$		360
0.064	96	Goldfish	LC$_{50}$		360
0.090	96	Carp	LC$_{50}$		360
0.037	96	Fathead Minnow	LC$_{50}$		360
0.068	96	Bluegill	LC$_{50}$		360
0.083	96	Smallmouth Bass	LC$_{50}$		360
0.032	96	Largemouth Bass	LC$_{50}$		360
0.027	96	Rainbow Trout	LC$_{50}$		360
0.002	96	Brown Trout	LC$_{50}$		360
0.041	96	Coho Salmon	LC$_{50}$		360
0.068	96	Yellow Perch	LC$_{50}$		360
0.4	96	Striped Bass	LC$_{50}$		410
0.13	96	Mosquito Fish	LC$_{50}$		450
0.05	96	Guppy	LC$_{50}$		450
0.06	96	Tilapia Mossambica	LC$_{50}$		450
0.04	96	Kuhlia Sandvicensis	LC$_{50}$		450
0.004	12	Stolephorus Purpurea	LC$_{50}$		450

Saltwater Toxicity

ppm	hr	Species	Parm	Cond.	Ref.
>10.0	48	Hard Clam	LC$_{50}$		411
>10.0	288	Hard Clam	LC$_{50}$		411
4.1	96	Oyster	LC$_{50}$		411
0.014	24	Sand Shrimp	LC$_{50}$		22
0.038	24	Hermit Crab	LC$_{50}$		22
0.062	24	Grass Shrimp	LC$_{50}$		22
0.38	96	Oyster	LC$_{50}$		23

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	125-200	Oral	22
Mouse	86	Oral	22
Rabbit	60-200	Oral	22

Species	mg/kg B. W.	Administration Route	Ref.
Guinea Pig	100-137	Oral	22
Rat	76	Oral	96
Avian Toxicity			
Young Mallards	>2000	Oral	22
Mallards	>5000 ppm	Oral - 5 Days	22
Pheasants	500-600 ppm	Oral - 5 Days	22
Bobwhite	900-1100 ppm	Oral - 5 Days	22
Coturnix	400-500 ppm	Oral - 5 Days	22

MALATHION

Malathion is one of the organo-phosphate insecticides used widely on fruit, vegetables, ornamentals, livestock, and households. The 20 million lbs produced in 1971 (327) were applied in the dust, wettable powder, concentrate, and emulsion concentrate forms.

Malathion is not very soluble in water, but when spilled in a wettable form, will soon disperse through the water column. Malathion hydrolyses rapidly and is subject to attack at the sulfur atom. Iron catalyses decomposition. In river water, 10 percent remains after two weeks , while none is detectable after four weeks (328). In soil, Laygo and Shuls reported persistence for two days. When applied at 5 lb/acre to silt-loam soil, 0.1 ppm of the original 3.2 ppm remained after 8 days (22).

Malathion is relatively toxic to fish. The 96 hr TLms for Atlantic salmon, bluegill, and fathead minnows have been reported as .12 ppm, (2); .09 ppm (329); and 12.5 ppm (330), respectively. The predicted 96 hr LC50 values for most gamefish fall in the range .1-.3 ppm. For rough fish and catfish, this range is extended to 12 ppm (360). Various fish food organisms are affected in the range .0009-0.1 ppm (330). Daphnia magna are immobilized by .009 ppm (335). In salt water, marine fish display a 96 hr LC50 of .008-3.2 and marine crustacea .033-.83 ppm (377).

Malathion is considered 100 times less toxic than parathion. The oral LD50 values for mice and rats have been reported as 4000(8) and 2830(1) mg/Kg body weight, respectively. The estimated fatal dose for a 70 Kg man is 60 gms (1). Drinking water should not contain more than 0.1 ppm malathion (337). In chronic feeding studies, rats satisfactorily tolerated 1000 mg/Kg in diets for six months. Similarly, no effect were noted in rats fed 5000 mg/Kg of diet for 63 consecutive days (1). Tests for carcinogenesis have been negative (15), but malathion is suspected of reacting with DNA (19). In tests for teratogenesis, chicks fed 75 ppm/day had congenital malformations (15).

Birds are fairly tolerant of malathion. The LC50s for mallard ducks and pheasants have been determined as >5000 ppm and 2,500-4,500 ppm, respectively (22). Chickens fed as little as 100 mg/Kg body weight develop leg weakness (22).

Malathion is not considered to be highly phytotoxic When added to 0.1 ppm, malathion can be converted to malaoxon and other metabolites by algae. The malathion did alter the composition of the mixed algal community but there was no persistent inhibitory effect on growth (22).

NAME Malathion

PRODUCTION QUANTITY 30 million lbs - 1971

SYNONYMS O,O-Dimethyl Phosphorodithioate of Diethyl Mercaptosuccinate; Malathon; Phosphothion; MPN; American Cyanamide-4049; #4049

M.P. 2.9 °C

B.P. 157 °C

Sp.G. 1.23

SOLUBILITY 25°C - 145 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
.031	24	Atlantic Salmon	TLm		1
.12	96	Atlantic Salmon	TLm		1
5.0		Trout	100% Kill		1
5.0		Yellow Perch	100% Kill		1
0.090	96	Bluegill	TLm		329
0.10	24	Trout	50% Kill		329
12.5	96	Fathead	TLm	Soft Water	330
12.5	96	Fathead	TLm	Hard Water	330
.100	24	Rainbow	LC50		330
.120	24	Bluegill	LC50		330
.0009	48	Daphnia Magna	TLm	59% Active in Xylene	330
.0056	96	Acroneuria Pacifica	TLm	59% Active in Xylene	330
.100	96	Pteronarcys Californica	TLm	59% Active in Xylene	330
.056	96	Claassenia Sabulosa	TLm	59% Active in Xylene	370
.032	96	Arctopsyche Grandis	TLm	59% Active in Xylene	330
8.970	96	Catfish	TL50	Predicted	360
12.9	96	Bullhead	TL50	Predicted	360
10.7	96	Goldfish	TL50	Predicted	360
8.65	96	Minnow	TL50	Predicted	360
6.59	96	Carp	TL50	Predicted	360

ppm	hrs	species	parm	cond	ref
.17	96	Sunfish	TL50	Predicted	380
.103	96	Bluegill	TL50	Predicted	380
.205	96	Bass	TL50	Predicted	380
.170	96	Rainbow	TL50	Predicted	380
.400	96	Brown	TL50	Predicted	380
.101	96	Coho	TL50	Predicted	380
.003	96	Perch	TL50	Predicted	380
.0036	24	Chaoborus Astictopus	4th Instar Larvae		379
.17	24	Fall Chinook Fingerling	TLm		378
.15	48	Fall Chinook Fingerling	TLm		378
.13	96	Fall Chinook Fingerling	TLm		378
.05	24	Mosquito Fish	40% Lethal	In Acetone	371
.021	96	Chinook			
.004	96	Threespine Stickleback	TLm		369
13.6	96	N. Saltatus Hydrofica	TLm	Soft	374
11.4	96	N. Saltatus Hydrofica	TLm	Soft	374
8.9	96	N. Saltatus Hydrofica	TLm	Soft	374
.21	96	Fathead Minnow	TLm	100% Tech.	380
.09	96	Bluegill	TLm	100% Tech.	380
.04	96	Guppy	TLm	100% Tech.	380
.00163	96	Gammarus Lacustris	TLm	In Acetone	358
.05	96	Pteronarcys Californica (Naiad)	TLm		367
.007	96	Acroneuria Pacifica (Naiad)	TLm	95% Active In Acetone	367
77	96	Rainbow	TLm	Temp 45°F	381
86	96	Rainbow	TLm	Temp 55°F	381
110	96	Rainbow	TLm	Temp 65°F	381
.1	96	Ephemerella Grandis	TLm		333
.007	96	Hydropsyche Californica	TLm	Soft	333
.003	48	Simocephalus Serrulatus	EC50		356
.002	48	D. Pulex	EC50		356
.0009	64	D. Magna	Immob.	Temp 72°F	336

ppm	hrs	species	parm	cond	ref
.0002	64	D. Carinata	Immob.	Temp 78°F	330
.005	24	Rainbow	TLm	Mo. River	381
.0046	48	Rainbow	TLm	Mo. River	381
.0029	96	Rainbow	TLm	Mo. River	381
.0023	120	Rainbow	TLm	Mo. River	381
.04	24	Red Shiner	TLm	Mo. River	381
.036	48	Red Shiner	TLm	Mo. River	381
.025	96	Red Shiner	TLm	Mo. River	381
.022	120	Red Shiner	TLm	Mo. River	381
.115	96	Bluegill	TLm		438

Salt Water Toxicity

.15	48	Killifish	50% Kill		367
.1		Spot	70% Enzyme Activity		376
.1		Sheepshead Minnows	30% Enzyme Activity		376
.008-3.2	96	Marine Fish	LC50		377
.033-0.81	96	Marine Crustacea	LC50		377

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	4000	Oral	9
Rat	1000	Oral	1
Rat	2830	Oral	1

MALEIC ACID

Maleic acid is employed for processing textiles, synthesizing plastics, manufacturing dyes, and making pharmaceuticals. It is presently supplied by six major U. S. firms.

Maleic acid is very soluble in water. When spilled, the white crystals will sink and dissolve rapidly, dropping the solution pH. The dissolved acid will then be diluted and neutralized by receiving waters until it is present as the soluble calcium and sodium salts. (Calcium maleate is soluble to 20,000 ppm.) The maleate anion is biodegradable. As much as .38 lbs of oxygen per lb of acid are utilized in the first 5 days (11). Acclimation can accelerate this to .63 lbs oxygen (4). This should not be sufficient, however, to produce oxygen deficiencies in a spill situation.

The 96 hr median threshold limit for mosquito fish in turbid water is reported to be .230 ppm maleic anhydride (1). The 48 hr value for bluegill in Philadelphia tap water is .138 ppm (1). It is estimated that a safe level would be 35 ppm (1). Solution pH and buffer capacity will be important in determining resulting toxicity.

Maleic acid is a strong irritant, highly toxic when ingested or inhaled. The oral LD_{50} for the anhydride to rats is reported as 850 mg/kg body weight (8). Chronic administration of 0.06 mg/kg daily for six mo. affected the glycogen synthesizing liver function in rats. Similar doses of 6 mg/kg for five mos. decreased phagocytic activity in rabbits (15).

A concentration of 1 ppm in reservoir water produced no organoleptic effects in man (15).

NAME Maleic Acid

SYNONYMS cis Butenedoic Acid, Maleinic Acid, cis-1,2-Ethylenedicarboxylic Acid, Malenic Acid, Toxilic Acid

M.P. 130. °C

B.P. 135. °C Decomposes

Sp.G. 1.590

SOLUBILITY Very Soluble

PERSISTENCE

Oxygen Demand

BOD.5 = 0.52 Theo.-(32)
BOD$_1$ = 0.76 Theo.-(32)
BOD$_5$ = .38 lb/lb using sewage seed-(11)
BOD$_5$ = .63 lb/lb using acclimated seed-(4)
BOD$_5$ = .77 ppm/ppm (anhydride)-(156)
COD = .83 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
35		Bluegill	Estimated Safe Concentration		1
240	24-48	Mosquito-Fish	Tlm	Turbid, 20-23°C	1
230	96	Mosquito-Fish	Tlm	Turbid, 20-23°C	1
150	24	Bluegill	Tlm	Philadelphia Tap	1
150	48	Bluegill	Tlm	Philadelphia Tap	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	850	Oral-as anhydride	151

MALEIC ANHYDRIDE

Maleic anhydride is employed to produce pharmaceuticals, resins, dyes, and diene compounds. The 220.6 million lbs produced in 1971 (100) were shipped in bags and fiber drums in the dry form and in tank cars and trucks in the molten form.

Production is predicted to increase 12-15 percent/yr through 1975.

Maleic anhydride hydrolyses to maleic acid when dissolved in water. Its biodegradability and aquatic toxicity will be the same as that noted for maleic acid.

Maleic anhydride is highly toxic when ingested or inhaled. The oral LD50 for rats is 850 mg/kg body weight (131). Chronic administration of 0.5 mg/kg daily for six months and 5 mg/kg daily for five months produced no effects in rabbits (15). No chronic effects are known to accompany intake by man (98).

NAME Maleic Anhydride

PRODUCTION QUANTITY 228.6 million lbs 1971 (188)

SYNONYMS cis-Butenedioic Anhydride

COMMON SHIP OR CONTAINER SIZE Bags, fiber drums, molten in tank cars, tank trucks

M.P. 52.8 °C

B.P. 202. °C

Sp.G. 1.314

SOLUBILITY 163,000 mg/l at 30°C

__PERSISTENCE__

__Chemical Hydrolysis, etc.__

Becomes maleic acid when dissolved.

__TOXICOLOGICAL__

__Fresh Water Toxicity__

See Maleic Acid

__Salt Water Toxicity__

See Maleic Acid

__Mammalian__

__species__	__mg/kg B. W.__	__administration route__	__ref.__
Rat	850	Oral	18

MERCURY

Mercury may appear naturally as a free metal or as a salt. It is commonly found near ore deposits of other precious metals. Salts including mercuric acetate, mercuric chloride, mercuric cyanide, mercuric nitrate, and organo-mercury compounds are used in industry for disinfection, preservation, fabric printing, tanning, electroplating, ink production, explosives manufacture, electrolytic cells (chlor-alkali industry), and medicinal preparations. Total U.S. mercury consumption was greater than 6 million lbs in 1969 (315).

Natural levels of atmospheric mercury have been recorded as 2 mg/m^3 air (315) whereas a survey of principal rivers in the U.S., 1958-59, detected no mercury contamination. Nine separate water supplies in Denver, Colorado were found to contain .05 mg/l (56). The sources for this contamination included industrial operations and mining activities. Recent surveys of water supplies in general revealed up to 5 ppb mercury (315). Sewage sludge has been found with as much as 87 ppm mercury (315). Mercury has been detected in a wide variety of animal life. Concentrations in aquatic life vary from 0.1 ppm found in bottom organisms to 5.0 ppm found in predatory fish (315). Specific studies have also identified mercury in fur seals (316), upland game birds (317), migratory waterfowl (318), and man (315).

While metallic mercury is insoluble, many mercuric and organo-mercuric compounds are soluble. These will disperse soon after spillage. The sulfate and phosphate salts are relatively insoluble, however, and will precipitate out in natural waters with a subsequent drop in the dissolved mercury level. Mercury may also sorb onto particulate matter and be carried to the bottom. Once mercury reaches the bottom environment, it undergoes a complex series of chemical and biological interactions resulting in the production of dimethyl and methyl mercury. The proportional split between these depends largely on pH and dissolved oxygen content. Aerobic conditions and low pH move equilibrium toward the more toxic methyl mercury (320). Methylation is slow, 1-5 mg/cm^2/week, and hence mercury deposits in sediments may require decades to purge themselves to natural background levels (321).

Mercuric ions are considered highly toxic to aquatic life. Concentrations of 0.004-0.02 mg/l as Hg have been reported as harmful to freshwater fish (1). Concentrations of .01-.1 are lethal to microlife (309). For phytoplankton, the minimum lethal concentration has been reported as 0.9-60 mg/l (1). In aerated salt water, LC50 values of .075 mg/l, 5.7 mg/l, 4.2 mg/l, and 9 mg/l have been reported for prawn, shrimp, oyster, and cockle respectively (2). The 48 hr TLm for marine fish in general is given as 0.27, but levels as low as .008 can be lethal (109). A threshold concentration of .01 ppm has been recommended for waters with fresh or saltwater fishes (41).

Mercury, especially methylated mercury, is concentrated in fish in the liver, kidneys, spleen, bone, and brain. Pike in water containing .07 ppb mercury concentrated it 3000 times. The biological half-life is reported to be 44 days.

Mercury salts are extremely toxic by all routes of exposure. The oral LD50 for rats fed mercuric chloride is reported to be 37 mg/kg body weight (1). A dose of 1 gm of mercury can be fatal to humans as can consumption of water containing 50 mg/l (208). The Soviet Union restricts mercury in drinking water to .005 ppm or less (56). While as little as 1.7 mg/kg mercuric chloride can cause acute fatal poisoning in humans (56), mercury poses the greatest threat through chronic exposure. Slow accumulation of mercury, particularly methyl mercury, can lead to destruction of the central nervous system over the period of exposure.

Mercury

Mercury has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use if determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

MERCURY

PRODUCTION QUANTITY - 139 million lbs redistilled in 1969 - (199)

SYNONYMS - Hydrargyrum

COMMON SHIP OR CONTAINER SIZE - 76 lb flasks

M.P. = -38.87°C

B.P. = 356.58°C

Sp.G. = 13.59

SOLUBILITY Insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Sulfate and phosphate insoluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	harm	cond	ref
.01-.1		Microlife	Lethal		209
.03		Daphnia Magna	Threshold		61
0.5-1	48	Carassius Auratus	TLm		322
5	10	Carassius Auratus	Lethal		321
.01	6	Stickleback	Lethal	15-18°C	110
.1	60	Aspergillus Niger	LD50	Added as HgO	114
0.2		Tench,Carp, Trout,Char, Crustacea,Worms, Insect Larvae	Not Harmful		1
0.9-60		Phytoplankton	Minimum Lethal Con.		1
.013	96	Pumpkinseed	LC_{50}		439

Saltwater Toxicity

ppm	hrs	species	harm	cond	ref
0.29	48	Marine Fish	TLm		109
0.01		Paracentrotus Lividus Eggs	Severe Disturbance		109
0.005		Paracentrotus Lividus Eggs	Retards Development		109
0.008	240	Marine Fish	Kill		109
0.08	24	Marine Fish	Kill		109

Mammalian Toxicity

Species	mg/kg B.W.	administration route	ref
human	1 mg/M	inhalation	98
rat	400	intraperitoneal	98
rabbit	20 mg/M	inhalation	98

MERCURIC ACETATE

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

M.P. 178-180°C

B.P. - decomposes

Sp.G. - 3.28

SOLUBILITY - 250,000

PERSISTENCE

Chemical Hydrolysis, etc. - Upon standing, soltions decompose yeilding a yellow precipitate. Any of these forms, however, can be resolubilized through biological action which leads to a cycling mechanism.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of mercury ion.

MERCURIC CYANIDE

USCG - Poison B, Poison Label

IATA - Poison B, Poison Label

M.P. - Decomposes

Sp.G. - 4.018

SOLUBILITY - 93,000 mg/l at 14° C
539,000 mg/l at 100° C

PERSISTENCE - Dissociation yields mercuric ion and cyanide. The cyanide ion is in equilibrium with HCN, a very weak acid.

TOXICOLOGICAL

FRESHWATER TOXICITY - Toxicity will be that for mercury ion

MAMMALIAN TOXICITY

Species	mg/kg B.W.	Administration Route	Ref.
Rat	25	Oral LD50	88

MERCURIC NITRATE

SYNONYMS - Mercury Pernitrate

M.P. 79°C

B.P. - Decomposes

Sp. G. - 4.39

SOLUBILITY - Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Mercury will associate with particulate matter or precipitate as a common salt, e.g., sulfate, oxide, etc. Subsequent biological action may resolubilize mercury initiating cycling between the aqueous and sediment phases.

TOXICOLOGICAL

Freshwater Toxicity

Mercuric Nitrate

0.02 as Hg	7 Days	Stickleback	Lethal	Very Soft	1
0.02 as Hg		Guppy	LD_{50}		1
1.0		Australorbis Snails	30% Kill		1
3.6		Australorbis Snails	90% Kill		1
1.7	48	Stickleback	TL_m		1
0.015		Isopod	First Significant Effects		1
0.015		Fish	First Significant Effects		1
1.0		Polychaete	First Significant Effects		1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Mouse	5 Low Lethal Dose	Intraperitoneal	66

MERCURIC SULFATE

SYNONYMS - Mercury Bisulfate, Mercury Persulfate

DOT - Poison B, poison label, 200 lbs in an outside container

USCG - Poison B, poison label

M.P. - Decomposes

Sp. G. 6.47

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Mercury sulfate decomposes in water to an insoluble basic sulfate. Subsequent biological action can resolubilize the mercury initiating cycling between aqueous and sediment phases.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the mercury.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	57	Oral	440

MERCURIC THIOCYANATE

SYNONYMS = Mercuric Sulfocyanate, Mercuric Sulfocyanide

DOT = Poison B, poison label, 200 lbs in an outside container

IMCO = Poison B, poison label

B.P. = Decomposes

SOLUBILITY

PERSISTENCE

Chemical Hydrolysis, etc. = Mercury will associate with particulate matter. Subsequent biological action can resolubilize the mercury initiating cycling between the aqueous and sediment phases.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that of the mercury itself.

MERCUROUS NITRATE

M.P. - 70°C

Sp. G. - 4.79

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposes to mercuric form. Mercury is quickly complexed with sediments but can be remobilized biologically and is bioaccumulative.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for mercury ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Mice	4	Intraperitoneal	96

METHOXYCHLOR

Methoxychlor is a polychlorinated aromatic insecticide similar in structure to DDT. It is primarily used on fruits, vegetables, livestock, and in households. The 10 million lbs produced in 1971 (327) were applied in granule, dust, wettable powder, and emulsion concentrate forms.

Methoxychlor is slightly soluble in water. It will disperse through the water column, however, if spilled in a wettable form. Little is known of the water chemistry of methoxychlor, but it is not likely to be nearly as persistent as DDT. Tests show a much lower accumulation potential for methoxychlor than DDT indicating susceptibility to metabolic degradation or excretion (1).

Methoxychlor is highly toxic to aquatic life. The 96 hr TLm to common fish species falls in the range .035-.120 ppm (1). For rainbow trout, the value is .0028 ppm (369). Fish food organisms are immobilized in the concentration range .00078-.005 ppm (330). In salt water, marine fish display a 96 hr TLm of .012-.15 ppm and marine crustacea .004-.014 ppm (377).

Methoxychlor is subject to biological concentration. Oysters exposed to 0.05 ppm in flowing seawater concentrated methoxychlor by a factor of 5700. Brook trout placed in .005

ppm exceeded 1,700 ppm after seven days. This is considerably lower than accumulation levels seen with DDT. When placed in fresh water, contaminated fish eliminated 61.3 percent of the accumulated toxicant in one week (88).

Methoxychlor is not highly toxic when ingested. The oral LD50 for rats is 5000-7000 mg/kg body weight (5). The estimated fatal dose for a 70 kg man is 350 gms (5). Drinking water should not contain more than .035 ppm (107). With chronic feed studies, toxicity was noted at 10 mg/kg in rats over a two year period (5). Feeding studies with rats have also shown tumor development (10).

Birds appear quite sensitive to methoxychlor. The LD50 for young mallard ducks was 15.0 mg/kg when administered orally (90). Bobwhite quail fed .1000 mg/kg in diet suffered a 40 percent reduction in reproduction.

Methoxychlor has phytotoxic properties. Exposure of phytoplankton communities for four hrs to 1 ppm resulted in an 80.0 percent reduction in productivity (88).

NAME Methoxychlor

PRODUCTION QUANTITY 10 million lbs 1971

SYNONYMS 1,1-bis(p-methoxyphenyl)-2,2,2-trichloroethane; [illegible]

M.P. 78 °C

Sp.G. 1.41

SOLUBILITY Slightly

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	EFFECT	COND	REF
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	In Acetone	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	In Acetone	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	In Acetone	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	In Acetone	[illegible]
[illegible]		Mosquito Fish	50 Lethal	Pond	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	Mosquito Fish	Lethal		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	100 Lethal	Flowing	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ppm	hrs	species	[illegible]	[illegible]	ref
Salt Water Organisms					
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible] Fish	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
		[illegible]			

Mammalian

species	mg/kg B. W.	administration route	ref.
Rat	[illegible]	Oral	[illegible]
Rat	[illegible]	Oral	[illegible]
Bobwhite Quail	[illegible],000	Oral	[illegible]

Methyl Mercaptan

Methyl mercaptan or Methanethiol is used in the production of jet fuels, pesticides, plastics and miscellaneous chemicals. It is presently produced by seven major U. S. firms for shipment in 800 lb cylinders, tank cars and tank trucks.

Methanethiol is soluble in water to 23,300 ppm. It is doubtful that saturated solutions will occur from transportation spills, since the compound is a gas and the water-gas interface is likely to occur for a minimum amount of time. When dissolved, mercaptans are slightly more acidic than alcohol. In alkaline solutions, mercaptans quickly form mercaptides. These salts are soluble unless there is a sufficient concentration of heavy metals in the water which will then form an insoluble precipitate. Mercaptans are a typical product of anaerobic bacterial action. They may well be susceptible to aerobic degradation, but no oxygen demand data are available.

Methanethiol has been reported to kill fish in the .5-1 ppm range (1). Hayden et al. studied king salmon, silver salmon and cutthroat trout to determine both an [illegible] and a safe concentration. The TLm values were 0.9, 1.75, and 1.0 ppm respectively, while safe concentrations were 0.3, 0.7, and 0.0 ppm (1). Daphnia and insect larvae are killed by concentrations in the range 1-60 ppm (1).

Methanethiol is considered an ingestive and inhalative toxin. The subcutaneous LD_{50} for mice is reported as 2.4 mg/kg body weight (150). The lethal concentration for rats in air is 10,000 ppm (6). Mercaptans are also irritants. The compound in solution or air has good warning properties. The lowest taste threshold is listed as .0011 ppm (6).

NAME Methyl Mercaptan

SYNONYMS Methanethiol, Methyl Sulfhydrate, Mercaptomethane, Thiomethyl Alcohol

COMMON SHIP OR CONTAINER SIZE 800 lb cylinders, tank trucks, tank cars

DOT Flammable gas, Red gas label, 300 lbs outside container

USCG Inflammable gas, red gas label

M.P. -123. °C

B.P. 5.95 °C

Sp.G. 0.867 as a liquid

SOLUBILITY 23,300 mg/l at 20°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	exam.	cond	ref
[illegible]	[illegible]	White Bass	Death	Lake Water	1
[illegible]	[illegible]	Sunfish, Bluegill	Death	Lake Water	1
[illegible]	[illegible]	Rock Bass	Death	Lake Water	1
[illegible]	[illegible]	Shiners	Death	Kraft Pulp Mill wastes	1
[illegible]		Minnows	Death		1
[illegible]	[illegible]	King Salmon	Death	[illegible] °C	1
[illegible]	[illegible]	King Salmon	No Deaths	[illegible] °C	1
[illegible]	[illegible]	Silver Salmon	Death	[illegible] °C	1
[illegible]	[illegible]	Silver Salmon	No Death	[illegible] °C	1
[illegible]	[illegible]	Cutthroat Trout	Death	[illegible] °C	1
[illegible]	[illegible]	Cutthroat Trout	No Death	[illegible] °C	1
[illegible]		Daphnia Magna, Mayfly Larvae	Death		1
50		Chironomus Larvae	60% Death		1

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	2.4	Subcutaneous	[illegible]

METHYL METHACRYLATE

Methyl methacrylate is employed in the production of methacrylate resins and plastics. The 450 million lbs produced in 1969 (198) were shipped in bottles, cans, drums, tank cars, and tank barges.

Methyl methacrylate is only very slightly soluble. When spilled, it is likely to float on the surface in a colorless slick and dissolve very slowly. The exposed slick will be subject to photochemical attack at the unsaturated bond. The dissolved portion is biodegradable. As much as 47 percent of the theoretical oxygen demand may be satisfied in the first 10 days (10). This is not a sufficient rate to cause oxygen slumps in spill situations.

Methyl methacrylate is toxic to fish. The reported 96 hr TLm values for minnows, bluegill, goldfish, and guppy are 150, 250,240, and 420 ppm, respectively (37). The undissolved slick will also pose a threat to waterfowl and marine mammals.

Methyl methacrylate is considered a slight toxicant (38). The oral LD50 for rats is listed as 9400 mg/Kg body weight (15). The same value for dogs is somewhat lower - 4700 mg/Kg body weight (108). The vapors are mildly irritating. A TLV of 100 ppm has been established. Chronic administration in drinking water showed weight depression in rats at the 2000 ppm level as well as increased kidney to body weight ratios (153). Similar effects were found in dogs at the 100 ppm level, except that it was the spleen which obtained abnormal size (153).

NAME Methyl Methacrylate

PRODUCTION QUANTITY 450 million lbs 1969 (198)

SYNONYMS Methacrylic Acid, Methyl Ester, Methyl-2-Methyl-2-
propenoate

COMMON SHIP OR CONTAINER SIZE Bottles, cans, drums, tank cars,
tank barges

DOT Flammable Liquid, Red Label, 10 gal outside container

USCG Grade C flammable liquid

M.P. -50 °C

B.P. 101. °C

Sp.G. 0.936

SOLUBILITY Very slightly soluble

PERSISTENCE

Oxygen Demand

BOD_{10} = 47% Theo. using CO_2 evolution data from sewage seed (10)
BOD_{20-21} = 42-49% Theo. using CO_2 evolution measurements (96)
BOD_{22} = 68% Theo. using CO_2 evolution data from acclimated seed (26)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para.	cond	ref
130	96	Fathead Minnow	TLm	Const. Temp.	17
350	96	Bluegill	TLm	Const. Temp.	17
240	96	Goldfish	TLm	Const. Temp.	17
420	96	Guppy	TLm	Const. Temp.	17

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	8400	Oral	15
Dog	4700	Oral	103
Guinea Pig	6000	Oral	103

METHYL PARATHION

Methyl parathion is an organophosphate insecticide used primarily to control boll weevils. The 45 million lbs produced in 1971 (327) were applied in the wettable powder, solution, and emulsion concentrate forms.

Methyl parathion is practically insoluble in water, but will disperse through the water column if applied in a wettable form. Like most organo-phosphate control agents methyl parathion hydrolyzes rapidly. In river water, 10 percent may remain after two weeks, and this disappears in an additional two weeks (328). Muhlmann and Schrader report persistence in water of 60^{a} days at 20 °C (22). The half-life of methyl parathion on cotton leaves is one hr (1). When applied to silt-loam soil, 0.1 ppm of the original 1.2 ppm persisted for 90 days (22).

Methyl parathion can be quite toxic to aquatic life. The 96 hr TLm values for fathead minnows, bluegill, goldfish, and guppies have been reported as 7.5 ppm (8), 1.9 ppm (329), 12 ppm and 9.0 ppm (372) respectively. Crawfish are more sensitive, exhibiting a 72 hr TLm at .04 ppm (366). Fish food organisms display 48 hr LC_{50} values in the range .00078 for Daphnia to .041 for Stoneflies (22). In saltwater, the 96 hr TLm to grass shrimp is 0.003 ppm (141).

Methyl parathion is extremely toxic to man. The estimated fatal dose is 2.1 mg/kg body weight (1). In rats, the oral LD_{50} has been reported as 9-25 mg/kg (1). Drinking water should not contain more than 0.1 ppm (207). In chronic feeding studies, adverse effects were noted in rats and rabbits fed 1 mg/kg daily for six months (15). Methyl parathion is suspected of reacting with DNA. In tests for teratogenesis, mice developed cleft palate (18).

In birds, methyl parathion is reported to have an LD50 level of 10 mg/kg for young mallard ducks, and 8.2 mg/kg for pheasants. Median lethal concentrations range from 60-84 ppm for coturnix to 600-700 ppm for mallard ducks. Chickens fed 24 mg/kg developed leg weakness.

[illegible] [illegible]

PRODUCTION QUANTITY [illegible] million lbs - 1971

SYNONYMS [illegible]

M.P.: [illegible] °C

Sp.G. [illegible]

SOLUBILITY [illegible] ppm at [illegible] °C

TOXICOLOGY

Fresh Water Toxicity

ppm	hrs	species	form	cond	ref
[illegible]	[illegible]	Fathead	TLm	Hard Water	[illegible]
[illegible]	[illegible]	Fathead	TLm	Soft Water	[illegible]
[illegible]	[illegible]	Bluegill	[illegible]		[illegible]
[illegible]	[illegible]	Bluegill	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	TLm	[illegible]	[illegible]
[illegible]	[illegible]	Guppy	TLm	[illegible]	[illegible]
[illegible]	[illegible]	Chaoborus Astictopus	Fourth Instar Larvae		[illegible]
[illegible]	[illegible]	[illegible]	TLm		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	Bluegill	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Predicted	[illegible]
[illegible]	[illegible]	Perch	[illegible]	Predicted	[illegible]

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	[illegible]	Oral	[illegible]
Rat	[illegible]	Oral	[illegible]

Saltwater Toxicity

ppm.	Hr	Species	Form	Cond.	Ref.
[illegible]	[illegible]	Grass Shrimp	TLm		[illegible]

Mevinphos

Mevinphos, or Phosdrin, is an organophosphate used as a systemic insecticide -- acaricide. The less than 1 million pounds produced in 1971 were applied as emulsifiable concentrates, water soluble solutions, and dusts to control aphids, mites, grasshoppers, cutworms, leafhoppers, caterpillars, and other insects on a broad range of field crops.

Mevinphos is miscible in water and will spread quickly when spilled. Like other organophosphates, it hydrolyzes in water and will not persist.

Mevinphos is toxic to aquatic life. The 96 hour LC_{50} to bluegill and rainbow trout is 0.022 ppm and 0.012 ppm respectively (338). Alabaster (409) has found that 48 hour LC_{50} to harlequin fish somewhat higher: 11.5 ppm. Fish food organisms are also adversely affected at low levels. The 96 hour LC_{50} for P. californica naiad is 0.005 ppm (186). Simocephalus serrulatus and Daphnia pulex are immobilized when exposed for 48 hours to 0.00043 and 0.00016 ppm respectively (335).

In saltwater the 24 hour LC_{50} values for sand shrimp, hermit crabs, and grass shrimps are 0.011, 0.131, and 0.040 ppm respectively (22).

MEVINPHOS

SYNONYMS - Phosdrin, 2-Carbomethoxy-1-methylvinyl dimethyl phosphate, OS-2046, [illegible], [illegible]

PRODUCTION = <1,000,000 lb/yr 1971

B.P. = [illegible]

Sp. G. = [illegible]

SOLUBILITY = Miscible

PERSISTENCE

Chemical Hydrolysis, etc. - Hydrolyzes in water. Short lived.

[illegible]

Freshwater Toxicity

ppm	hr	Species	Test	Cond.	Ref.
[illegible]	[illegible]	Rainbow Trout	Lethal	Flowing Temp [illegible]	[illegible]
0.1	[illegible]	Rainbow Trout	Lethal	Flowing Temp [illegible]	[illegible]
[illegible]	[illegible]	Eastern Brook Trout	Lethal	Flowing Temp [illegible]	[illegible]
[illegible]	[illegible]	Eastern Brook Trout	Lethal	Flowing Temp [illegible]	[illegible]
10.0	[illegible]	Eastern Brook Trout	Lethal	Flowing Temp [illegible]	[illegible]
[illegible]	96	Pteronarcys californica (Naiads)	LC_{50}	Temp 60°F	[illegible]
[illegible]	48	Simocephalus serrulatus	Immobilized	Temp 60°F	[illegible]
[illegible]	[illegible]	Daphnia pulex	Immobilized	Temp [illegible]	[illegible]
[illegible]	[illegible]	P. californica (Naiads)	LC_{50}	Temp [illegible]	[illegible]
[illegible]	[illegible]	Rainbow Trout	LC_{50}		[illegible]
[illegible]	[illegible]	Rainbow Trout	LC_{50}		[illegible]
[illegible]	[illegible]	Rainbow Trout	LC_{50}		[illegible]
[illegible]	[illegible]	Bluegill	LC_{50}		[illegible]
[illegible]	[illegible]	Bluegill	LC_{50}		[illegible]
[illegible]	[illegible]	Bluegill	LC_{50}		[illegible]
[illegible]	[illegible]	Harlequin Fish	LC_{50}		[illegible]

Saltwater Toxicity

ppm	hr	Species	Test
[illegible]	[illegible]	Hermit Crab	LC_{50}
[illegible]	[illegible]	Sand Shrimp	LC_{50}
[illegible]	[illegible]	Grass Shrimp	LC_{50}

Cation Exchanger

Species	gm/Kg B. W.	Administration Route	Ref.
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Anion Exchanger

Species	gm/Kg B. W.	Administration Route	Ref.
[illegible]	[illegible]	Oral	[illegible]
[illegible]	[illegible]	Oral	[illegible]
[illegible]	0.70-1.0	Oral	[illegible]

[illegible]

Monoethylamine

Monoethylamine, or ethylamine is used in medicine, dye production organic synthesis, resin formulationsand oil refining. The 88.1 million lbs produced in 1976 (100) were shipped as a solution in carbon steel drums, tank cars and tank trucks.

Ethylamine is typically shipped as a solution or pressurized liquid. It is miscible with water, forming an alkaline solution. The caustic reaction is believed to be the result of dissociation of the amine group to form an ammonium ion. In strong alkaline solutions this could lead to the release of ammonia gas. The dissolved amine is likely to undergo moderately rapid biodegradation much as butylamine does. No data are available, however, and oxygen slumps are not expected in spill situations.

Ethylamine is toxic to fish in the 40-400 ppm range (1). The lower level is reported as a TLm for chub while the upper was lethal to sunfish(1). Fish food organisms are sensitive to concentrations of 10-40 ppm (1). Solution pH and buffer capacity will be critical parameters in determining resulting toxicity because of the possibility for free ammonia.

Ethylamine is highly toxic via all routes of administration including skin absorption. The oral LD50 for rats is reported as 400 mg/kg body weight for 6 mos, a level which also caused a change in the albumin/globulin coefficient of rabbits (10). Conditioned reflexes were impaired in rats with daily administration of 0.5 mg/kg body weight for 6 mos (10). Carcinogenic reaction tests have been negative (10).

NAME Monoethylamine

PRODUCTION QUANTITY 30.1 million lbs 1970 ([illegible])

SYNONYMS Ethylamine, Aminoethane

COMMON SHIP OR CONTAINER SIZE Carbon steel drums, tank cars, tank trucks

DOT Flammable Liquid, Red Label, 10 gal. outside container

M.P. -80. °C

B.P. 16.6 °C

Sp.G. 0.689

SOLUBILITY Miscible

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	eff	cond	ref
100*	48	Daphnia	Toxic	23°C	1
90*		Microregma	Toxic		1
15*	96	Scenedesmus	Toxic	24°C	1
600-800	1*	Lepomis Humilis	Lethal	Tap	[illegible]
40	24	Chub	TLm	Aerated, 15-21°C	4
200*	1	Sunfish	Killed		[illegible]
40*	48	Creek Chub	Lethal		[illegible]

Mammalian

species	mg/kg D. M.	administration route	ref
Rat	400	Oral	[illegible]
Mouse	530-580	Oral	[illegible]

Monomethylamine

Monomethylamine, or methylamine is used in tanning operations and for synthesis of organic compounds. The 20.7 million pounds produced in 1970 (190) were shipped both in the gaseous state and in solution. Gases are generally contained in steel cylinders, tank cars, and tank trucks, while solutions are packaged in steel drums, tank cars, and tank barges.

Methylamine is very soluble in water. Spills of gases may not result in massive contamination because of the minimal gas-water contact. Spills of solutions, however, will lead to high concentrations of the amine. Methylamine has an alkaline reaction with water. This is believed to result from the dissociation of the amine group and subsequent formation of ammonium ions. Highly alkaline solutions may in fact release ammonia gas. The dissolved amine is subject to some biological attack. This is slower than with other amines and is not likely to cause oxygen deficiencies in a spill situation.

Methylamine is toxic to fish. The critical range for creek chub is reported as 10-30 ppm (1). Rainbow trout exposed to 141 ppm died within 33 minutes (1). Fish food organisms were killed by concentrations of 4-600 ppm of the hydrochloride salt (8). Due to the potential release of ammonia and the alkaline reaction, solution pH and buffer capacity will be critical parameters in determining resulting toxicity.

Methylamine is highly toxic when ingested or inhaled. The average oral LD_{50} for mammals falls in the range 8-40 mg/kg body weight (19). A threshold dose of .1 mg/kg body weight or 5 mg/l in drinking water has been reported for rats (18). Amine solutions can be irritating with prolonged contact.

Other aquatic concentrations of interest include a taste threshold range of .08-4.81 ppm (80).

NAME Monomethylamine

PRODUCTION QUANTITY 88.7 million lb 1970 (198)

SYNONYMS Aminomethane, Methylamine

COMMON SHIP OR CONTAINER SIZE Gas: steel cylinders, tank cars,
tank trucks, Solutions: Steel drums,
tank cars, barges

DOT (anhydrous): Flammable gas, Red Gas Label, 300 lbs outside container
(Solution): Flammable liquid, Red Label, 10 gal outside container

USCG (anhydrous): Inflammable gas, red gas label
(Solution): Inflammable liquid, red label

M.P. -93.5 °C

B.P. -6.3 °C

Sp.G. 0.699 as liquid

SOLUBILITY 959,000 mg/l at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
30	24	Chub	Died	Aerated, 15-21°C	1
161	.5	Trout	Died	pH 10.3, 13°C	1
10	24	Chub	Died		15

Mammalian

species	mg/kg B. W.	administration route	ref
Mammals	0.02	Oral	15
Mice	2500	Subcutaneous	8

END

NALED

Naled or Dibrom is a non-systemic insecticide-acaricide with some residual fumigant action. It is employed on numerous crops as well as in barns, kennels, and food processing plants. It is not approved for use in grain bins. Annual production is approximately 5 x 10^6 lbs.

Naled is very slightly soluble in water and aliphatic solvents while readily soluble in aromatic solvents. A solid in pure form, the technical material is a moderately volatile liquid. Upon standing in solution, either form hydrolyses. Biological degradation is likely.

Naled has been found to be quite toxic to fish and other aquatic life. The 24 hr LC_{50} for bluegills is reported as 0.22 mg/l while for brook trout the 48 hr LC_{50} values for stonefly, water fleas, and amphipods have been reported as 0.018 mg/l, 0.10 mg/l, and 0.0035 mg/l, respectively.[11]

Naled is also considered quite toxic to mammalian and avian species. The oral LD_{50} for rats is reported as 430 mg/kg body weight.[11] With dermal application, rabbits displayed an LD_{50} of 1100 mg/kg body weight.[111] Oral LD_{50} values for game birds lie in the range 30-76 mg/kg body weight.[11]

NALED

PRODUCTION QUANTITY - 2 x 10^6 lbs/yr

SYNONYMS - 1,2-Dibromo-2,2-Dichloroethyl Dimethyl Phosphate,
Bromex, Dibrom

M.P. 26°C

B.P. 110°C

Sp. G. = 1.97

SOLUBILITY - Very slightly soluble

PERSISTENCE

Dibrom hydrolyzes upon standing in water.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond	Ref
0.22	24	Bluegills	LC_{50}	--	22
1.1	24	Rainbow Trout	LC_{50}	1.6°C	22
0.62	24	Rainbow Trout	LC_{50}	7.2°C	22
0.24	24	Rainbow Trout	LC_{50}	12.7°C	22
0.078	48	Brook Trout	LC_{50}	--	22
2.2	24	Chorus Frog Tadpoles	LC_{50}	--	22
0.0011	48	Simocephalus serrulatus	EC_{50} (12°)	--	22
0.00035	48	Daphnia pulex	EC_{50} (15°)	--	22
0.027	24	Pteronarcys californica	LC_{50}	--	22
0.24	24	Gammarus lacustris	LC_{50}	--	22
0.016	48	P. californica	LC_{50}	--	22
0.16	48	G. lacustris	LC_{50}	--	22
4.0	48	Red Crawfish	LC_{50}	--	22
0.0035	48	Daphnia pulex	LC_{50}	--	22
0.18	96	Bluegill	LC_{50}	--	103

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Rat	430	Oral	22
Mule Deer	300	Oral	22
Rabbit	1100	Dermal	405

Avian Toxicity

Mallards	52.2	Oral	22
Sharp-Tailed Grouse	64.9	Oral	22
Canada Geese	30.9	Oral	22
Mallards	>5000 ppm LC_{50}	Oral-in food	22
Pheasants	2400-2700 LC_{50}	Oral-in food	22
Bobwhites	2000-2100 LC_{50}	Oral-in food	22
Coturnix	1200-1400 LC_{50}	Oral-in food	22

NAPHTHALENE

Naphthalene is used as a raw material for the production of phthalic anhydride as well as smokeless powder, resins, moth repellant, insecticides, hydronaphthalenes, and other chemicals. While production reached 633 million lbs in 1971 (109), it is expected to decline sharply in the future (108). Naphthalene is shipped as a solid in tins, barrels, bottles, and burlap bags; and as a molten liquid in tank barges.

Naphthalene is practically insoluble in water. When spilled, it will sink and remain on the bottom with little dissolution. Loose naphthalene will volatilize at room temperature releasing a moth ball-like odor. Dissolved, it is biodegradable under certain conditions. While sewage seed showed no oxygen demand after 5 days (11) activated sludge can utilize up to 50.5 percent of the theoretical demand in 6 days (143). Murray and Stone report that typically naphthalene is degraded first to salicylic acid, then to catechol and B-ketoadipic acid (230). A second route results in 1,2-naphthoquinon which colors the culture reddish orange(230).

Naphthalene is toxic to most fish. A concentration of 4 ppm was sufficient to kill sunfish in one hour (1). Perch died in 20 ppm while 15 ppm was fatal to minnows in 6 hrs (1).

Use of distilled water in the [illegible] test lowered the concentration necessary to 11 ppm (5). The critical level for disqualifying salmon in aerated seawater is reported to be 1.0 ppm (5). Fish placed in a 1 ppm solution soon displayed noticeable changes in flesh flavor(5).

Naphthalene is moderately toxic with ingestion or inhalation (10). The average oral LD50 for mammals is 1000-2,00 mg/kg body weight (10). A dose of 5-15 gms can kill humans (10). Tests for carcinogenesis have been negative (10).

The median odor threshold for naphthalene has been reported at 50 ppm (7).

NAME Naphthalene

PRODUCTION QUANTITY 432 million lbs 1971

SYNONYMS White Tar, Naphthalin, Naphthene, Tar Camphor

COMMON SHIP OR CONTAINER SIZE Tins, barrels, burlap bags, bottles, in
tank barges in a molten state

USCG (solid) Combustible Grade E solid
(liquid) Grade C Flammable Liquid

M.P. 80.2 °C

B.P. 217.9 °C

Sp.G. 1.162

SOLUBILITY 30 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

BOD_5 = 29.1% Theo. with activated sludge-(143)
BOD_5 = 0 using sewage seed-(11)
BOD_5 = 50.5% Theo. with activated sludge-(143)
ThOD = 3.00 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
5	1	Sunfish	Death		1
20		Perch	Killed		1
11	6	Minnows	Killed	Distilled 18°C	1
15	6	Minnows	Killed	Hard, 18°C	1
220	24	Mosquito-Fish	TLm	Turbid, 22-24°C	1
165	48	Mosquito-Fish	TLm	Turbid, 22-24°C	1
150	96	Mosquito-Fish	TLm	Turbid, 22-24°C	1
4-5	1	Sunfish	Lethal		102
<20		Perch	Lethal		145

Salt Water Toxicity

ppm	hrs	species	resp	cond	ref
1.8	72	Fingerling Salmon	Critical	Aerated	1

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

NAPHTHENIC ACID

Naphthenic, or cyclohexanecarboxylic acid, is employed in preparing fertilizer, refining petroleum, synthesizing rubber, producing insecticide, and performing chemical analysis. Production reached 37,000,000 lbs in 1968 (102).

Naphthenic acid is only slightly soluble. When spilled, the crystals will sink and dissolve very slowly. Heavy metal salts of this organic acid are insoluble and will precipitate out. Dissolved acid should be biodegradable at a moderate rate, but no quantitative data are available.

Naphthenic acid is reported to be quite toxic to fish and fish food organisms. A concentration of 4-16 ppm killed European perch[1]. Similar doses were lethal to crayfish and minnows (1). The 96 hr TLm values for bluegill, pulmonate snails, and diatoms are 7.1, 11.7, and 70.8 ppm, respectively (1). Other fishfood organisms are killed in the same range. While toxicity is not greatly affected by temperature or hardness, low oxygen tensions can reduce threshold levels considerably (1).

Naphthenic acid is considered moderately toxic with ingestion and inhalation. High concentrations can be narcotic. Direct contact may lead to irritation.

NAME Naphthenic Acid

PRODUCTION QUANTITY 37,000,000 lbs 1969 (102)

SYNONYMS Cyclohexanecarboxylic Acid, Hexahydrobenzoic Acid

M.P. 30. °C

B.P. 232.5 °C

Sp.G. 1.050

SOLUBILITY 2010 mg/l at 15°C

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	DATA	COND	REF
5-16		European Perch	Death		1
5-20	18-60	Crayfish	Death		1
5.6	96	Bluegill	TLm	Soft	1
7	72	Minnows	Death		1
7.1	96	Bluegill	TLm	Hard	1
7	96	Pulmonate Snail	TLm	Soft	1
11.7	96	Pulmonate Snail	TLm	Hard	1
43	96	Diatom	TLm	Soft	1
78.6	96	Diatom	TLm	Hard;22°C	1
66	96	Diatom	TLm	Hard; 28°C	1
30.2	96	Diatom	TLm	Hard;30°C	1
6.6-7.5	96	Physa Heterostropha	TLm		137
8	96	Physa Heterostropha	TLm	Low O_2	137
43.1	120	Nitzschia Linearis	TLm		130
16.3	48	Brachydanio Rerio (Adults)	TLm	24°C	133
3.5	48	Brachydanio Rerio (Eggs)	TLm	24°C	133

NICKEL

Nickel belongs to the iron-cobalt group of metals. It is an important constituent of alloys and is used to provide protective or decorative coating for other metals.

Elemental nickel is very insoluble in water; however the salts (nickel chloride, nickel sulfate, nickel nitrate, and nickel ammonium sulfate) are very soluble in distilled water. In natural waters the solubility varies with water quality characteristics such as pH, hardness, and alkalinity. Bryan reports that in sea water the solubility ranges from 20-400 mg/l and that NiOH is the possible form of the precipitate.

More than half of the nickel and nickel salts are transported by rail in bottles and wooden kegs. The remainder is shipped by truck and barge.

Nickel is found in sea water at a concentration of about 0.0054 mg/l. (43) Rapp and Kroner found that at several selected fresh water stations dissolved nickel ranged from 0.003 to 0.086 mg/l, and suspended nickel varied from 0.005 to 0.9 mg/l. (283)

Schroeder states that nickel appears to be almost ubiquitous in vegetation. He also reported little or no nickel in edible animal products. Nickel was found in the liver and kidneys of many wild birds and animals. He also reported 0.14 to 0.20 ug/g (wet weight) nickel in the liver of salmon. (301)

Bryan reported 0.58 ppm (wet weight) Ni in the whole body minus shell for the scallop, Chlamys opercularis, and 10.0 ppm (wet weight) in the renal organs. (260)

Nickel may interfere with natural biological systems in receiving waters.

Toward Scenedesmus the threshold of toxicity is 0.09 mg/l, toward E. coli, 0.1 mg/l, and toward Microregma 0.07 mg/l as nickel. A nickel concentration of about 27 mg/l from nickel ammonium sulfate caused a 50 percent reduction in the oxygen utilization from synthetic sewage. (1)

The maximum level in a continuous feed of nickel which did not produce a detectable effect on an activated sludge pilot plant was between 1 to 2.5 mg/l. A 200 mg/l slug dose of nickel caused a serious reduction in treatment efficiency for a few hours but the plant returned to normal performance in 40 hours. Barth et al. reported that of the metallic wastes received by municipal wastewater treatment plants nickel was removed least effectively; it passed through the plant almost entirely in the soluble form.

McKee and Wolf reported that the toxicity of nickel to aquatic life varied with species, pH, and other water quality characteristics. Jones found that 1 mg/l of nickel in soft water was toxic to the stickleback. (1) Pickering and Henderson reported that the 96 hr TL50 of nickel in soft water (20 mg/l)* varied from 4.6 to 9.8 mg/l for four species of warm water fishes; nickel was more toxic in soft water (20 mg/l)* than in hard water (360 mg/l)*. (300) Pickering found 96 hr

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*Hardness equivalent to $CaCO_3$

TL50 values of 27 and 30 mg/l of nickel in hard water (200 mg/l)* for the fathead minnow in static bioassays, which was similar to continuous flow bioassay values of 25 and 28 mg/l. In the chronic tests 0.73 mg/l of nickel had an adverse effect on fathead minnow egg production and hatchability of these eggs. At concentrations of 0.38 and less no effects on survival, growth, or reproduction were found. (203) Warnick and Bell reported that the 96 hr TL50 values for two species of aquatic insects were 4.0 and 33.5 mg Ni/l. (204) Biesinger and Christensen reported that the 48 hr LC50 for Daphnia magna in Lake Superior water (45 mg/l hardness) was 0.51 mg Ni/l. In their chronic bioassay (three weeks) 0.05 mg Ni/l gave a reproduction impairment of 50 percent and a concentration of 0.03 mg/l had no effect. (202)

Nickel is one of the relatively nontoxic heavy metals found in the tissues of man (201). Its physiological role in mammals has not been determined but is possibly concerned with pigmentation.

The oral LD50 for nickel carbonate fed to rats has been reported as 250-1000 ppm in water. That for nickel chloride fed dogs is 1.5-10 mg/kg body weight. (15) Large doses can irritate gastro-intestinal tissues causing vomiting and diarrhea. A single dose of 500 mg may be fatal to dogs. (15) Chronic administration of 250 ppm nickel carbonate in water led to reduced growth in calves. (15) Nickel chloride, however, had no effect on cats and dogs when fed at 4-12 mg/kg/day for 200 days. (15)

No limits have been established for nickel in drinking water in the U.S. but the Soviet Union restriction is 0.1 ppm. (18)

Nickel is extremely toxic to citrus fruits. It is found in many soils in California, generally in insoluble form, but excessive acidification of such soils may render it soluble causing severe injury or death of plants. Nickel was toxic at 0.5 mg/l to flax grown in water culture. Concentrations of 15.0-29.4 mg/l of nickel in nutrient solutions were injurious to sugar beets, tomatoes, potatoes, oats, and kale grown in sand culture. (1)

NAME Nickel

PRODUCTION QUANTITY 33.5 million lbs. sulfate - 1971 (199)

M.P. 1455 °C

B.P. 2730 °C

Sp.G. 8.9

SOLUBILITY Insoluble, most common salts soluble

PERSISTENCE

Chemical Hydrolysis, Etc.

Hydroxide will precipitate out.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
.8	-	Stickleback	Lethal	-	1
.05	48	Rainbow Trout	TLm	River	105
10	-	Daphnia	Lethal	Lake	62
6	-	Daphnia Magna	Threshold	-	61
.9	48	Aspergillus Niger	LD_{50}	As Chloride	3,6
1000	8-10 1/2	Goldfish	Survival Time	Very Soft	100
1000	12-18	Goldfish	Survival Time	Hard	100
100	18.4-50.4	Goldfish	Survival Time	Very Soft	100
10	200-210	Goldfish	Survival Time	Very Soft	100
27	96	Fathead Minnow	TL_{50}		200

Salt Water Toxicity

ppm	hrs	species	para	cond	ref
.121	Long Term	Oysters	Lethal	-	44
.125	48	Marine Fish	TLm	-	109
12	24	Fish	Lethal	-	109
.8	240	Fish	Lethal	-	106

Mammalian

species	mg/kg B.W.	administration route	ref
Dog	60	Intravenous-Chloride	8
Dog	1.5-32	Oral-Chloride	15
Rat	250-1000	Oral-Carbonate	15
Rat	420	Oral-Nitrate	77
Dog	5.0	Subcutaneous-Sulfate	66

NICKEL AMMONIUM SULFATE

SYNONYMS - Ammonium Nickel Sulfate, Ammonium Disulfato Nickelate

M.P. - Decomposes on heating

Sp. G. - 1.923

SOLUBILITY - 25,000 at 20°C

PERSISTENCE

Chemical Hydrolysis, etc. - Carbonate and hydroxide salts of nickel will precipitate. Ammonium ion is subject to biochemical oxidation after 4-5 days.

TOXICOLOGICAL

Fresh-water Toxicity

ppm	hrs	Species	Test	Cond.	Ref.
6 as Ni	-	Daphnia Magna	Deleterious Effect		1
0.09	-	Scenedesmus	Toxic Threshold		1
0.1	-	E. coli	Toxic Threshold		1
0.07	-	Microregma	Toxic Threshold		1

NICKEL CHLORIDE

B.P. 973°C sublimes

Sp. G. = 3.55

SOLUBILITY = 2,540,000 mg/l @20°C

PERSISTENCE

Oxygen Demand

Chemical Hydrolysis, etc. - Basic salts such as carbonate and hydroxide are insoluble.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Farm	Cond.	Ref.
10		Goldfish	Death		1
100	10-50	Goldfish	Survive	Soft	1
4.5	200	Goldfish	Death		1
0.1	Few	Top Minnow, Fundulus	Death	Tap	1
4.0		Guppy	Median Lethal Dose		1
4.0	96	Fathead Minnow	Tlm	Soft	1
24	96	Fathead Minnow	Tlm	Hard	1
6.0 as Ni		Daphnia Magna	Threshold of Toxicity		1
0.7	64	Daphnia Magna	Threshold of Immobilization	25°C	1
0.1		E. coli	Threshold Concentration		1
8×10^{-6}M	4	Limnaea Palustris (eggs)	Killed		B-192
5.18	96	Fathead Minnow	Tlm	Soft	B-54
42.4	96	Fathead Minnow	Tlm	Hard	
5.18	96	Bluegill	Tlm	Soft	
39.6	96	Bluegill	Tlm	Hard	
9.82	96	Goldfish	Tlm	Soft	
4.45	96	Guppy	Tlm	Soft	

Saltwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
250		Top Minnow Fundulus	Survived		1

MAMMALIAN

Species	mg/kg B. W.	Administration Route	Ref.
Dog	60	Intravenous	8
Dog	1.5-10	Oral	443

NICKEL FORMATE

M.P. - Decomposes

Sp. G. - 2.154

SOLUBILITY - Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Carbonate and hydroxide salts of nickel will precipitate. The formate anion is biochemically degradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of the nickel ion.

NICKEL HYDROXIDE

SYNONYMS - Nickelous Hydroxide

Sp. G. - 4.1

SOLUBILITY - 13 ppm in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - The presence of carbonate can reduce solubility even further.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of nickel ion.

NICKEL NITRATE

COMMON SHIP OR CONTAINER SIZE - Glass bottles, wooden kegs

M.P. 56.7°C

B.P. 137°C

Sp. G. - 2.05

SOLUBILITY - 2,385,000 mg/l 0°C

PERSISTENCE

Oxygen Demand

Chemical Hydrolysis, etc. - Hydroxide and carbonate salts are insoluble.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
2.44		Stickleback	Threshold Concentration	Tap	1
45		Polycelis Nigra	Toxic		1
1.0	168	Stickleback	Lethal Concentration	15-18°C	1
1.5	96	Stickleback	Lethal Concentration		1
.8	24	Stickleback	Lethal Concentration		1
0.8	240	Stickleback	Lethal Concentration		87

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1620	Oral	77

NICKEL SULFATE

SYNONYMS - Morenosite

PRODUCT QUANTITY - 33.8 million lbs - 1971 (199)

M.P. 31°C loses water

B.P. 103°C loses water

Sp. G. - 2.07

SOLUBILITY - 625,000 mg/l @25°C

PERSISTENCE

Oxygen Demand

Chemical Hydrolysis, etc. - Hydroxide and carbonate salts are insoluble.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
50	48	Stickleback	Killed	Tap	1
160	48	Rainbow Trout	TLm		177
270	48	Brown Trout	TLm		177
242	48	Brook Trout	TLm		177
75	48	Lake Trout	TLm		177
165	48	Channel Catfish	TLm		177
495	48	Bluegill	TLm		177
33.5	96	Acroneuria	TLm		81
4.0	96	Ephemerella	TLm		81

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
13.0	48	Prawn	LC_{50}	Aerated	3
125	48	Shrimp	LC_{50}	Aerated	3
>500	48	Cockle	LC_{50}	Aerated	3
255	48	Crab	LC_{50}	Aerated	3
100-150	48	Oyster	LC_{50}	Aerated	3

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Dog	500	Subcutaneous LD_{LO}	85

NITRIC ACID

Nitric acid is a transparent, colorless (or yellowish, if exposed to light) fuming, suffocating, caustic and corrosive liquid. It is a very strong oxidizing agent and will attack most metals. About 13 billion lbs were produced in 1971 in the U.S. (199). About 75 percent of the acid produced is used for fertilizer. Five--ten percent is used in the manufacture of cyclohexanone for eventual manufacture of nylon. Similar quantities are used in a large number of other organic syntheses.

Small quantities are used for stainless-steel pickling, metal etching, as a rocket propellant. Containers include carboys, glass bottles, 55 gallon drums, rail tank cars, and tank trucks.

Nitric acid is freely soluble in water, and will rapidly disperse when spilled. Exposure to light causes the release of nitrogen dioxide which will be accompanied by a yellowish brown discoloration. Natural buffer capacity and dilution will neutralize the spill slowly leaving a residual nitrate concentration.

Nitric acid is toxic to fish primarily through its ability to lower the solution pH below the critical level of 5. The ability to do this in a spill situation will depend upon receiving water pH, alkalinity, and buffer capacity. Laboratory bioassay evaluations indicate that concentrations as low as 1.6 ppm can be lethal to trout (1). Similarly, 72 ppm, 200 ppm, and 750 ppm have been lethal to mosquito fish, minnows, and goldfish, respectively.(1) Daphnia are immobilized at 107 ppm (1). LC50 value for marine species fall in the range 100-1000 ppm (2). After neutralization has removed the acute toxic hazard, residual nitrates may still pose a threat to aquatic life through over fertilization resulting in excessive algal blooms.

Nitric acid is highly corrosive to tissue as well as toxic via all exposure routes. Water for drinking should not contain more than 15-30 ppm nitric acid or free nitrates(1). Water for livestock should not exceed 400 ppm nitrates(4).

NAME Nitric Acid

PRODUCTION QUANTITY 13 billion lbs 1971

SYNONYMS Aqua Fortis

COMMON SHIP OR CONTAINER SIZE Glass bottles, carboys, 55 gal stainless drums, tank cars, tank trucks, aluminum drums

DOT Corrosive Liquid, White Label, 5 pts in outside container

USCG Corrosive liquid, white label

M.P. -41.6 °C

B.P. 86 °C

Sp.G. 1.502

SOLUBILITY - >1,000,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc.

Sunlight sponsors release of NO_2.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	result	cond	ref
1.0		Trout	Toxic		1
13.6	24	Trout	Toxic		1
72	96	Mosquito Fish	TLm	Turbid, pH 6.2	1
200		Minnows	Toxic		1
750	.5	Goldfish	Toxic	Hard, pH 3.4	1
1200	.5	Trout	Toxic	Tap	1
1000	[illegible]	Minnow	Toxic	pH 4.4	1
107		Daphnia	Threshold for immobilization		1

Reported Safe

ppm	hrs	species	result	cond	ref
5.75		Minnows	Not Harmed	pH 5.2	1
5.75		Shiners	Not Harmed		1
5.75-20		Fish	Not Harmed		1
20		Carp, Goldfish, Suckers	Not Harmed		1
200	100	Goldfish	Not Harmed		1
200	~96	Goldfish		pH 4.0	1

ppm	hrs	species	param	cond	ref
Salt Water Toxicity					
330-1000	48	Cockle	LC50	Aerated	[illegible]
100-330	[illegible]	Pogge	LC50	Aerated	[illegible]
100-330	48	Starfish	LC50	Aerated	[illegible]

NITROBENZENE

Nitrobenzene is used to produce aniline, oils, soaps, shoe polish, and pyroxylin compounds. The 540 million lbs produced in 1970 (188) were shipped in bottles, 55 gal metal drums, and tank cars.

Nitrobenzene is moderately soluble in water. When spilled, it will seek the bottom and dissolve slowly. Dissolved nitrobenzene is not subject to appreciable biodegradation. No 5-day oxygen demand is evidenced with sewage seed (11). A concentration of 610 ppm is capable of inhibiting sewage organisms 50 percent (1).

Nitrobenzene is toxic to fish and fish food organisms. Minnows were reported to die in 6 hrs when exposed to 90 ppm in hard water. A similar reaction resulted from a 6 hr exposure to 20 ppm in distilled water (1). Daphnia, microregma and scenedesmus are affected by 28 ppm, 30 ppm, and 40 ppm, respectively (1). Marine fish have a slight irritant response to 10 ppm (1). The undissolved, submerged layer of nitrobenzene may smother benthic life forms.

Nitrobenzene is highly toxic via all routes of administration. The average oral LD50 for mammals falls in the range 700-799 mg/kg body weight (15). Nitrobenzene can be absorbed through the skin at toxic levels. Aqueous solutions are detectable by odor at .03 ppm (1).

NAME Nitrobenzene

PRODUCTION QUANTITY 548 million lbs- 1970

SYNONYMS Oil of Mirbane

COMMON SHIP OR CONTAINER SIZE Bottles, 55 gal metal drums, tank cars

DOT Poison B, Poison Label, 55 gal in an outside container

USCG Poison B, Poison Label

M.P. 6. °C

B.P. 210. °C

Sp.G. 1.205

SOLUBILITY 1900 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD_5 = 0 lb/lb with sewage seed-(11)
COD = 1.39 lb/lb-(64)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	resp	cond	ref
20	6	Minnows	Lethal	Distilled, 22°C	1
90	6	Minnows	Lethal	Hard	1
28		Daphnia	Toxic		1
30		Microregma	Toxic		1
600		E. Coli	Toxic		1
40		Scenedesmus	Toxic		1
>100	72	Fathead Minnow	100% Kill	50°F, Huron	426
>100	72	Fathead Minnow	Potential Kill	50°F, Huron	426
40	72	Fathead Minnow	No Toxic Effect	50°F, Huron	426

Salt Water Toxicity

10		Marine Fish	Slight Irritant Activity

Mammalian

species	mg/kg B. W.	administration route	ref
Rabbit	700	Oral	1
Mammals	700-799	Oral	15

Nitrogen Dioxide

Nitrogen dioxide is commonly used in the production of nitric acid, sulfuric acid, explosives, bleach flour, rocket fuel, and hemostatic cotton. It is also employed as a nitration agent. It is typically shipped as a liquid in pressurized vessels.

Nitrogen oxide is a yellow or red brown gas which decomposes in water releasing nitrogen oxide and forming nitric acid which subsequently will be neutralized by dilution. Toxic reactions in water will be those arising from the action of the nitric acid hydrolysis product.

Nitrogen dioxide is a toxic gas and strong irritant. Upon inhalation it will cause slight chest pains resulting from lung inflamation. It may also cause edema. The low toxic concentration for man has been reported as 64 ppm.[11]

NITROGEN DIOXIDE

SYNONYMS - Nitrogen Tetroxide

COMMON SHIP OR CONTAINER SIZE - 125,150,200 lb cylinders, Tank Cars

DOT - (Liquid) Class A Poison, Poison Gas Label, not accepted outside container

USCG - Poison A (Liquid), Poison Gas Label

IATA - Poison A, not acceptable Passenger or Cargo

M.P. - -9.3°C

B.P. - 21.3°C

Sp. G. - 1.448 as liquid

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposes in water forming nitric acid.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that of nitric acid decomposition product.

Mammalian Toxicity

Species	Con. (ppm)	Administration Route	Ref.
Man	64	TC-Low Inhalation	92
Mouse	250	TC-Low Inhalation	96

NITROPHENOL

Nitrophenols are white or yellow crystalline solids which give intensely coloured salts. They are used as indicators (colorless in acid solutions; yellow in basic solutions) and as intermediates in organic synthesis. Production reached 34 million lbs in 1968 (199). Nitrophenol is transported by barge, rail, and truck, in glass bottles, fiber cans, and drums.

Meta-Nitrophenol is soluble in water. Para and ortho-nitrophenol are less soluble in descending order. When spilled, the solids will sink and dissolve slowly. Phenols are susceptible to addition reactions when chlorinated. The chlorinated products are typically more toxic than their precursors. Dissolved nitrophenol is not readily biodegradable. An acclimated bacterial culture may realize up to 42 percent of the theoretical oxygen demand in 94 days (5).

Nitrophenol is toxic to fish and fish food organisms. The 48 hr Tlm for bluegill is reported to be 46.3 ppm (15). Median lethal doses for 6 hr exposures of minnows to the three isomers fall in the range 4-18 ppm for distilled water and 20-130 ppm for hard water (1). Various fish food species are affected in the 20-28 ppm range (1). In general, phenol contact should be less than 1 ppm for freshwater fish, and 5 ppm for saltwater varieties (41). Nitrophenol is toxic to the algae chlorella pyrenoidosa at 9 ppm (4). Chronic aquatic toxicity limits are close to 1 ppm (42). Waterfowl should not be exposed to more than 25 ppm (41).

Nitrophenol is toxic when ingested or inhaled. The average oral LD50 for mammals is 300-399 mg/kg body weight(15). Recommended drinking water limits specify less than .001 ppm phenols, but this is predicated on organoleptic properties rather than toxicological factors (49). Phenols can be irritating. Fresh water for body contact should not contain more than 10 ppm phenols (40) and saltwater, 1 ppm (41).

NAME Nitrophenol

PRODUCTION QUANTITY 34 million lbs-1968 (includes sodium salts)

COMMON SHIP OR CONTAINER SIZE Glass bottles, fiber cans, drums

M.P. 97 °C

B.P. 194 °C

Sp.G. 1.485

SOLUBILITY 13,500 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD,94 - 4.2% Theo. with acclimated pure bacterial culture-(5)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
24		Daphnia	Toxic	23°C	1
28		Scenedesmus	Toxic	24°C	1
20		Microregma	Toxic		1
300		E. Coli		27°C	1
46.3	48	Bluegill	TLm		15

Ortho isomer

ppm	hrs	species	[illegible]	cond	ref
14-18	6	Minnow	MLD	22°C,Dist.	1
125-130	6	Minnow	MLD	22°C,Hard	1

Meta isomer

ppm	hrs	species	[illegible]	cond	ref
9-10	6	Minnow	MLD	22°C,Dist.	1
20-22	6	Minnow	MLD	22°C,Hard	1

Para isomer

ppm	hrs	species	[illegible]	cond	ref
4-6	6	Minnow	MLD	22°C,Dist.	1
30-33	6	Minnow	MLD	22°C,Hard	1

Mammalian

species	mg/kg B. W.	administration route	ref
Lab Animals	328	Oral	15
Mammals	300-399	Oral	15
Dog	83	Intravenous-MLD	8

PARAFORMALDEHYDE

Paraformaldehyde is a polymerized form of formaldehyde used as a food additive. The estimated 80 million lbs produced in 1969 (198) were shipped in glass bottles, fiber drums, bags, and bulk containers of up to 2000 lbs capacity.

Paraformaldehyde is soluble in water if the polymer chain contains 12 or fewer monomers. Otherwise it is insoluble. When spilled, the lower chain granules will sink and dissolve. Higher chain polymers may hydrolyze into shorter chain fragments while dissolving. Biodegradation is likely to be slow if evident at all.

Paraformaldehyde is an irritant, toxic material when ingested or inhaled. The oral LD_{50} for rats is reported as 800 mg/kg body weight (85). A TLV of 5 ppm has been established for formaldehyde vapors.

NAME Paraformaldehyde

PRODUCTION QUANTITY Estimated 80 million lbs 1969 (128)

SYNONYMS Polymerized Formaldehyde, Formagene, Triformol, Polyoxymethylene

COMMON SHIP OR CONTAINER SIZE Glass bottles, fiber drums, bags, bulk containers up to 2000 lbs

M.P. 120. °C

Sp.G. 1.46

SOLUBILITY 170,000 mg/l at 25° C

TOXICOLOGICAL

Mammalian

Species	mg/kg B. W.	administration route	ref
Rat	800	Oral	85

PARATHION

Parathion is a deadly organo-phosphate insecticide used primarily on fruit and row crops. The 15 million lbs produced in 1971 (347) were applied in the dust, granule, wettable powder, liquid, and emulsion concentrate forms.

Parathion is practically insoluble in water, but will soon disperse through water if spilled in a wettable form. Parathion is readily hydrolysed and appears especially vulnerable to attack at the sulfur atom. Yeasts are capable of converting it to aminoparathion. Parathion is incompatible with solutions with a pH above 7.5 (1). When mixed with river water parathion did not persist beyond four weeks (328). Parathion applied to soil has been detected five years after application. At a dose of 1.2 ppm in silt-loam soil, 0.1 ppm parathion was measured after 90 days (22). Cases of poisoning have occurred from consumption of dirt contaminated six months prior to contact (1).

Parathion is toxic to most forms of aquatic life. The 96 hr TLm for fathead minnows, is 1.6 ppm (1) while the 24 hr value for trout is 2.0 ppm (329). Tilapia and mullet succumb to 0.5 and 0.125 ppm respectively after 96 hrs exposure (347). Various fish food organisms are affected in the range .0001-.0032 ppm (330). Daphnia magna are immobilized after 50 hrs in .0008 ppm (365). In salt water,

.01 ppm is toxic to brine shrimp (303), and spot suffer 50 percent losses at .018 ppm (347). Fish have been known to concentrate parathion to levels 80 times that in ambient water, and mollusks 50 times (22). Accumulation potential is considered high for repeated doses over short periods of time (38).

Parathion is considered highly toxic by all routes of exposure. The oral LD50 for rats has been reported at 2, 6.5, 8.1, 15, and 30 mg/kg body weight (1,15,327). For mule deer, the level is 22 mg/kg (165). The acute lethal dose for man is 10-20 mg (38). Drinking water should not contain more than 0.1 ppm (337). In chronic feeding studies, as little as 1 mg/kg caused plasma cholinesterase inhibition in dogs. Absorption of 5 mg will produce symptoms in man (1). Tests with onion root tips at doses of .0075 percent and higher caused C-mitosis (15). Parathion is suspected of reacting with DNA (19). In tests for teratogenesis, 0.1 mg/egg produced congenital malformations in chickens (15).

Birds are equally sensitive to parathion. The LD50 values for young mallard ducks, young pheasants, and house sparrows are 1.9-2.1 mg/kg, 12.4 mg/kg, and 3.4 mg/kg respectively. Median lethal concentrations are 250-275 ppm for mallard ducks, 350-380 ppm for pheasants, and 40-50 ppm for coturnix (22).

NAME Parathion

PRODUCTION QUANTITY 15 million lbs - 1971

SYNONYMS O,O-Diethyl O-P-Nitrophenyl Phosphorothioate; Alkron; Compound 3422; DNTP; DPP; Etilon; Penphos; Phoskil; Thiophos; Vapophos; Paraflow; Paraspray; E-605; Genithion, Paradust

M.P. 6 °C

B.P. 375 °C

Sp.G. 1.26

SOLUBILITY 20 ppm at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	MEAS	COND	REF
1.5		Goldfish	TLm		1
3.0		Goldfish	100% Kill		1
1.6	96	Minnow	TLm	Hard H_2O	1
1.4	96	Minnow	TLm	Soft H_2O	1
2.0	24	Trout	TLm		320
1.0	96	Carp	100% Kill		347
0.5	96	Tilapia	100% Kill		347
0.125	96	Mullet	100% Kill		347
2.0	24	Rainbow	LC50		330
.056	24	Bluegill	LC50		330
.0001	96	Acroneuria Pacifica	TLm	25% Active in Xylene	330
.0032	96	Pteronarcys Californica	TLm	25% Active in Xylene	330
.001	96	Arctopsyche Grandis	TLm	25% Active in Xylene	330
.0008	50	Daphnia Magna	LC50	25% Active in Xylene	330
2.5		Lymnaeid Snails	100% Lethal	Ditchwater	106
.71	96	Bluegill	TLm		364
.0008	50	D. Magna	Immobilized		365
.004	24	Mosquito Fish	33% Lethal		371
1.3	96	Fathead Minnow	TLm	Soft	380
.095	96	Bluegill	TLm	Soft	380
2.7	96	Goldfish	TLm	Soft	380
.056	96	Guppy	TLm	Soft	380
.0128	96	Gammarus Lacustris	TLm	In Acetone	358
.0028	96	Acroneuria Pacifica	TLm		333
.003	96	Ephemerella Grandis	TLm		333

ppm	hrs	species	resp	cond	ref
.0128	96	Gammarus Lacustris	TLm		333
.034	96	Pteronarcys Californica	TLm		333
.00037	48	Simocephalus Serrulatus	Immobilized	Temp 60°F	335
.00037	48	D. Pulex	Immobilized	Temp 60°F	335
3-5	96	Tubifex + Limnodrilus Spp	LD50		363

Salt Water Toxicity

ppm	hrs	species	resp	cond	ref
.018	48	Spot	50% Kill		347
.03	24	Brine Shrimp	Lethal		303
.01		Spot	10% Enzyme Activity		370
.01		Sheepshead Minnow	26% Enzyme Activity		370
.007	48	Shrimp	Est. LC_{50}	Aerated	413

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	3 to 50	Oral	1
Rat	6.5	Oral	329
Rat	8.1	Oral	329
Mule Deer	8.1	Oral	37

Pentachlorophenol

Pentachlorophenol is a common wood preservative and algacide shipped in fiber drums and multi-walled paper sacks. It is often used to treat pilings and fence posts prior to installation.

Pentachlorophenol is a dark colored flake solid soluble to 80 ppm in water. It is highly resistant to biodegradation and chemical attack. When spilled, it will sink and remain at the bottom as a continual source of low levels of dissolved material.

Limited data suggests that pentachlorophenol is quite toxic to aquatic life. Wilbur[10] reports a toxic threshold to rainbow trout and Daphnia of 0.75 ppm. It is further reported that the toxic threshold for fish in general is 1 ppm phenols in freshwater and 5 ppm in saltwater.[1]

Pentachlorophenol is a strong irritant toxic when ingested, inhaled, or contacted with skin. The oral LD_{50} for mammals is reported as 100-199 mg/kg body weight.[1] A dose of 257 mg/kg body weight can be fatal to man.[1] Chronic administration to rats is fatal at 40 mg/kg/day. Tests for carcinogenisis have been negative, but mutagenic action in plant cells can occur.[1]

PENTACHLOROPHENOL

SYNONYMS - Penta, Santophen 20, PCP, Dowicide G

COMMON SHIP OR CONTAINER SIZE - Fiber Drums, Multi-Walled Paper Sacks

IATA - Other restricted article, Class A, No Label Required, No Limit

M.P. 190°C

B.P. 309°C

Sp. G. - 1.978

SOLUBILITY - 80 ppm

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
20		Green Sunfish	Repellent		420
5	3	Trout	Lethal		5
5	3	Bluegill	Lethal		5
.75		Rainbow Trout	Toxic Threshold		109
.50		Perca Fluviatilis	Toxic Threshold		109
.40		Rutilus Rutilus	Toxic Threshold		109
.75		Gammarus Lacustris	Toxic Threshold		109
.75		Daphnia	Toxic Threshold		109
2.5		Limnaea Ovata	Toxic Threshold		109

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	180	Oral	8
Mammals	100-199	Oral	17
Rat	420	Intraperitoneal-Lethal	111

PHENOL

Phenol is used as a disinfectant, analytical agent, and intermediate. It is also present as a by-product in a variety of waste streams. The 1,744,733 lbs produced in 1971 (109) were shipped in bottles, cans, drums, tank cars, and tank barges.

Phenol has been involved in massive spills in the past.

Phenol may be shipped as a light pink crystal or as a concentrated solution containing 50 percent benzo-phenol. The solid is soluble to 67,000 ppm and will sink, then dissolve when spilled. The solution is a heavy liquid and will also sink when spilled. The concentrated solution may maintain its strength and remain at the bottom of the waterway, causing a layered effect. This stratification has been observed to exist for a considerable period of time indicating phenol does not disperse rapidly in water. Phenols form a weakly acidic solution. They are highly reactive in various situations. In the presence of acids they undergo addition reactions such as nitration. Phenols can also pick up chlorine rapidly to form more objectionable compounds. Perhaps most important of its aqueous reactions is oxidation. Phenols, especially those in alkaline solutions, are readily oxidized to form a complex mixture of products, including quinone and phenoquinone when the oxidant is air.

Dissolved phenol is also subject to biodegradation. As much as 1.2-2 lbs of oxygen may be utilized per lb of phenol in the first five days (11), a rate which may be sufficient to cause localized oxygen deficiencies. In the presence of plants and soil the overall degradation rate approaches 3-5 mg/l/day. Without soil and plants, the rate declines to 2 mg/l/day (1). Experiments designed to test persistency have shown that a concentration of 1 ppm can be biologically assimilated at 20°C in 1-7 days. At 4°C, 5-10 days are required; and under anaerobic conditions, degradation is even slower (1).

Phenols are highly toxic to fish. Extensive tests show a wide range of overlapping values for the toxic threshold of phenol. Concentrations as low as .079 have killed minnows, while trout died within 8.5 hours when exposed to .4-.6 ppm (1). The Halsbands report a disturbance threshold in trout of 1.3 ppm phenol (1). Phenols in general should be maintained below 1 ppm for healthy fish propagation (41). Fish food organisms and other aquatic life do not appear to be as sensitive to phenol as fish. The threshold effect for various aquatic species is evidenced in the range 1-1600 ppm (1). A concentration of 10 mg/l is sufficient to inhibit photosynthesis in giant Kelp by 50 percent (1). Phenol is toxic to the algae chlorella pyrenoidosa in the range

233-1980 ppm (4). Aquatic toxicity, especially fish, has been found to increase with decreasing dissolved oxygen concentrations, increasing temperatures, decreasing hardness, and increasing salinity. The effect of combinations of different phenolics is additive.

Salt water species also exhibit high sensitivities to phenol. The 48 hr TLm for rainbow trout in diluted saltwater is 1.5 ppm (155). Acclimation raises that value to 5 ppm (155). Various other forms of marine life are affected by 17.5-500 ppm in aerated saltwater (2).

Phenol is highly toxic via all routes of administration. The oral LD50 for rats is reported as 530 mg/Kg body weight (8). As little as 1.5 gms can be fatal to man, but the average fatal dose is closer to 15 gms (1). Taste rather than toxicity is the basis of the recommended drinking water limit of .001 ppm (1). Chronic administration of drinking water containing 7000 ppm phenol stunted growth in rats and increased mortality at birth (1).

Phenol can also be absorbed through the skin at toxic levels. Fresh water for body contact should not contain more than 10-50 ppm phenol, and saltwater concentrations should not exceed 1 ppm (41).

Other concentrations of interest include an odor threshold of .016-16.7 ppm (30), a suggested maximum of 50 ppm for irrigation water (1), and a recommended limit of 1000 ppm for water offered to livestock (1).

NAME Phenol

PRODUCTION QUANTITY 1,744,733 lbs 1971 (199)

SYNONYMS Carbolic Acid, Phenylic Acid, Phenyl Hydroxide, Hydroxybenzene, Oxybenzene, Phenic Acid

COMMON SHIP OR CONTAINER SIZE Bottles, cans, drums, tank cars, tank barges

DOT (Liquid containing 50% benzo-phenol) - Class B Poison, Poison Label, 55 gal outside container
(Solid) - Class B Poison, Poison Label, 250 lbs outside container

USCG Grade E combustible, Class B poison

M.P. 43. °C

B.P. 182. °C

Sp.G. 1.071

SOLUBILITY 67,000 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

BOD.5 - 19% Theo. using phenol acclimated treatment plant activated sludge-(5)
BOD_4 - 3.9 mg/l-(156)
BOD_5 - 4.7 mg/l-(156)
BOD_5 - 1.2-2 lb/lb using sewage seed-(11)
BOD_8 - 16% Theo. using aniline acclimated treatment plant activated sludge-(5)
COD - 2.28-3.2 lb/lb-(4)
BOD_5, 10, 15, 20 = 90, 89, 87, 96% Theo. in freshwater - (425
BOD_5, 10, 15, 20 = 55, 74, 78, 86% Theo. in saltwater - (425)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
Fish					
0.002		Mixed Fish	Safe		1
0.079		Goldfish	Safe		1
0.10		Fish	Safe		1
0.5		Fish	Safe		1
1.0	100	Goldfish	Safe		1

ppm	hrs	species	parm	cond	ref
1.3		Trout	Safe		1
2.7		Bluegills	Safe		1
3.0	48	Stickleback	Safe		1
5.0	24	Bluegills & Lamprey	Safe		1
9.0	2.5	Brook Trout	Safe		1
10	6	Carp	Safe		1
10		Fish	Safe		1
15		Fish	Safe		1
17.1	24	Minnows	Fish		1
20	1.5	Eels	Safe		1
19,000	Brief	Carp	Safe		1
Fish Food Organisms					
1		Platymonas	Limits Photosynthesis		1
3		Mytilias Edulis	Threshold Effect		1
5		Daphnia (Young)	Threshold Effect		1
8-10		Daphnia Magna	Killed		1
14		Daphnia (Adult)	Threshold Effect		1
15		Tubeworm	Threshold Effect		1
15		Isopod	Threshold Effect		1
16		Dapnia	Threshold Effect		1
25		Gammaridae	Lethal		1
30		Microregma	Threshold Effect		1
40		Scenedesmus	Threshold Effect		1
40-50		Culex Larvae	Threshold Effect		1
50		Isopod	Threshold Effect		1
50-60		Daphnia	Threshold Effect		1
94		Daphnia Magna	Immobilization		1
94-100		Snail	Toxic Action		1
100-120		Pionocypris	Threshold Effect		1
108		Diaptomus Oregonensis	Threshold Effect		1
122		Cyclops Vernalis	Threshold Effect		1

ppm	hrs	species	parm	cond	ref
150-180		Cyclops & Sayomia Larvae	Threshold		1
200		Tubifex	Toxic Action		1
200		Crustacea	Toxic Effect		1
200		Mollusca	Toxic Effect		1
251-261		Navicula	Toxic Effect		1
800-1000		Culex Pupae	Threshold Effect		1
1000		Protozoa	Toxic Action		1
1000		Rotifers	Toxic Action		1
1800		Bacteria	Toxic Action		1
Fish					
0.079	.5	Minnows	Toxic	River	1
0.28		Mixed Fish	Toxic	River	1
0.4-0.6	8.5	Fish	Toxic		1
0.5-1.0		Trout	Toxic		1
0.71	1	Sunfish	Toxic		1
1-5		Tench	Toxic		1
3-5		Fish	Toxic		1
4.3	12	Trout	Toxic	River	1
5.0	10	Trout	Toxic	Lake	1
5.0	24	Trout	Toxic		1
5.0		Perch	Toxic		1
5.0	24	Salmonids Embryos	TLm	10°	1
5-10		Fish	Toxic		1
5-10		Trout	Toxic		1
5-20	1	Sunfish	Toxic	Aerated	1
6.0		Perch	Toxic		1
6.0		Rainbow Trout	Toxic		1
6.2	24	Brook Trout	Toxic		1
7.5-12.5	1	Yearling Trout	Toxic	12°	1
9		Perch	Toxic		1
9-10		Trout	Toxic		1
9.5	2.5	Brook Trout	Toxic		1
10	2.0	Dobule	Toxic		1
10	72	Goldfish	Toxic	Hard	1
10		Fish	Toxic		1
10		Tench	Toxic		1
10-15		Fish	Toxic		1
10-20		Fish	Toxic	Non-aerated	1
11.5-20	96	Bluegill Sunfish	TLm	Standard, 20°	1
12		Perch	Toxic		1
12	2.5	Perch	Toxic	Soft, 18°	1
13.5	96	Bluegill Sunfish	TLm		1

ppm	hrs	species	parm	cond	ref
14.2	24	Minnows	Toxic	18°	1
14.5	24	Tench	TLm		1
15.5	48	Stickleback	TLm	Synthetic, 15°	1
16-20		Fish	Toxic		1
16.7	96	Fingerling Catfish	TLm	Tap	1
17		Minnows	Toxic		1
17	2.5	Minnows	Toxic		1
17	.3	Perch	Toxic		1
18-20	6	Minnows	Toxic	Hard, 17°	1
19	48	Bluegill Sunfish	TLm	Aerated, 20°	1
19.3	96	Bluegill Sunfish	TLm	20°	1
20	1.4	Roach	Toxic	21°	1
20		Fish	Toxic		1
20	1	Sunfish	Toxic		1
20		Minnows	Toxic	17°	1
20	.25	Minnows	Toxic		1
20-25		Fish	Toxic	Aerated, Hard 18°	
20.2	96	Bluegill Sunfish	TLm	Synthetic 20°	1
22.0	48	Bluegill Sunfish	TLm		1
23	.16	Perch	Toxic	Soft, 20°	1
24	96	Bluegill Sunfish	TLm	Distilled, 18°	1
24-28	6	Minnows	Toxic	18°	1
24.9	24	Carp	TLm	Hard, 20°	1
28.5	96	Bluegill Sunfish	TLm	Tap	1
28.9	48	Goldfish	Toxic	9.5°	1
30	2.5	Roach	Toxic		1
40	.5	Eels	Toxic		1
40	48	Fathead Minnows	TLm	Distilled	1
51	1.5-2.5	Goldfish	Toxic	Turbid, 23-26°	1
56	96	Mosquito-Fish	TLm	Tap	1
70-75	1	Sunfish	Toxic		1
100 or less	1	Fish	Toxic	18-23°	1
100		Goldfish	Toxic		1
333	24	Goldfish	Toxic		1
400	.25	Trout	Toxic	Tap	1
1000	Brief	Trout, Perch	Toxic	River	1
1000	Brief	Roach	Toxic		1

ppm	hrs	species	param	cond	ref
7.5	48	Rainbow Trout	Tlm		157
5.8	48	Rainbow Trout	Tlm		158
1000	.25-.50	Goldfish	Lethal		144
100	60-72	Goldfish	Lethal		144
10	>72	Goldfish	Lethal		144
70-75	1	Sunfish	Lethal		109
56	96	Mosquito-Fish	Tlm		109
5.7-20	96	Bluegill	Tlm		109
3-10		Fish	Lethal		145
1.3		Rainbow Trout	Threshold of Disturbance		1

Salt Water Toxicity

ppm	hrs	species	param	cond	ref
1.5	48	Rainbow Trout	Tlm	Diluted Salt Water	155
5	48	Rainbow Trout	Tlm	Acclimated	155
5	48	Atlantic Salmon	Tlm	Acclimated	155
17.5	48	Prawn	LC50	Aerated	2
23.5	48	Shrimp	LC50	Aerated	2
>500	48	Cockle	LC50	Aerated	2
33-100	48	Flounder	LC50	Aerated	2
90	48	Crab	LC50	Aerated	2
160	24	Brine Shrimp	Tlm		425
56	48	Brine Shrimp	Tlm		425

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	530	Oral	8

PHOSGENE

Phosgene is employed as a war gas and as a chlorinating agent for various organic synthesis processes. The 505,033,000 lbs produced in 1969 (199) were shipped as a gas in cylinders and as a pressurized liquid in tank cars.

Phosgene decomposes in water releasing carbon dioxide and hydrogen chloride. The acid will slowly neutralize with natural dilution. Spills of phosgene gas may result in most of the gas dissipating prior to contact with water. As a pressurized liquid, contact with water is more probable. Aquatic toxicity will be that of the hydrochloric acid produced.

Phosgene is an extreme irritant, highly toxic when inhaled. The lethal concentration for rats in air is 50 ppm (8). A TLV of 5 ppm has been established for phosgene. Irritation is evident at the 3-5 ppm level.

NAME Phosgene

PRODUCTION QUANTITY 505,023,000 lb 1969 (199)

SYNONYMS Carbonic Acid Dichloride, Carbonyl Chloride, Chloroformyl Chloride, Carbon Oxychloride

COMMON SHIP OR CONTAINER SIZE Cylinders, tank cars

DOT Class A Poison, Poison Gas Label, not accepted in outside containers

USCG Poison A, poison gas label

M.P. -118. °C

B.P. 8.02 °C

Sp.G. 1.392

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes in water to carbon dioxide and hydrochloric acid.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to hydrochloric acid.

Salt Water Toxicity

Refer to hydrochloric acid.

PHOSPHORIC ACID

Phosphoric acid is used to produce fertilizer, detergents, ethylene, hydrogen peroxide, soft drinks, dental cements, and latex. It is also employed for engraving and medicinal applications. The 12.5 billion lbs produced in 1971 (199) were shipped dry or in solution in boxed carboys, 15-30 gal. fiber drums, 15-55 gal stainless drums, tank cars, and tank trucks.

Phosphoric acid is freely soluble in water. It is typically shipped as a solution, which when spilled will sink and disperse. A heavy submerged layer may remain for a short period due to the high density of concentrated solutions. Although there are three types of phosphoric acids, in water the ortho form (H_3PO_4) will predominate. Dissociation is broken into three distinct stages according to the constants $1.1x10^{-2}$, $7.5x10^{-8}$, and $4.8x10^{-13}$. Natural buffer action and dilution will slowly neutralize spills.

Much like nitric and hydrochloric acid, phosphoric acid is toxic only when it lowers the solution pH below a value of 5 (1). A concentration of .01 ppm has been noted to kill stickleback, while the 24-96 hr Tlm for mosquito fish in turbid water has been reported to be 138 ppm (1). Solution pH, buffer capacity and alkalinity will be important in determining resulting toxicity in spill situations. Once the acute hazard has been mitigated, residual phosphate may still stimulate massive algal blooms resulting from over fertilization. The 96 hour TLm for bluegill is reported as 200 ppm (1). In saltwater the 96 hour TLm for brook trout is 934 ppm (443).

Phosphoric acid is an irritant, moderately toxic when ingested or inhaled (38). Toxic action, however, results from its corrosive nature rather than intrinsic toxicity.

NAME Phosphoric Acid

PRODUCTION QUANTITY 12.5 billion lbs-1971

COMMON SHIP OR CONTAINER SIZE Boxed carboys, 15-30 gal fiber drums, 15-55 gal stainless drums, tank cars, tank trucks

M.P. 42.35 °C

B.P. 213 °C Decomposes

Sp.G. 1.834

SOLUBILITY Freely Soluble

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	species	parm	cond	ref
.01		Stickleback	Lethal	pH 5	1
8		Gasterosteus Aculeatus	Lethal	Dist., pH 4	1
.2		Gasterosteus Aculeatus	Lethal	pH 3.2	1
138	24,48,96	Mosquito Fish	TLm	Turbid, 22-24°C	1
200	96	Bluegill	TLm		1

Saltwater Toxicity

ppm	hrs	species	parm	cond	ref
934	96	Brook Trout	TLm		443

PHOSPHOROUS

Phosphorous is employed as a building block for the production of rat poison, smoke screens, and various compounds. The 1 billion lbs of phosphorous produced in 1971 (199) were shipped under water in cans and drums and under water or inert gases in tank cars and tank trucks.

Yellow phosphorous is soluble in water to 3 ppm. Spills may result in both the release of elemental phosphorous which will sink and dissolve very slowly and "phossy" blanketing water which will quickly disperse in the water column. Elemental phosphorous reacts with oxygen to form phosphorous pentoxide which then hydrolyzes in water to phosphoric acid. The oxidation can occur from dissolved oxygen in water and, hence, elemental phosphorous will display an oxygen demand. Oxygen utilization is closely followed by increased acidity.

Isom reports that bluegills are killed in 163 hrs when elemental phosphorous levels reach .025 ppm (231). The effects are due to colloidal phosphorous rather than dissolved species. The phosphate hydrolysis product may fertilize waters and subsequently lead to algal blooms. In saltwater, the 91 hour TL_{50} for brook trout is 0.003 ppm (443).

Elemental phosphorous is extremely toxic when ingested. The estimated oral LD_{50} for rabbits is 7 mg/kg body weight (8).

The fatal dose for humans is 100 mg (231). Drinking water should not contain more than 0.1 ppm phosphorous (40). Chronic administration of as little as 1 mg/day elemental phosphorous can cause liver and bone damage (231). Elemental phosphorous is also a strong irritant.

NAME Phosphorous

PRODUCTION QUANTITY 1 billion lbs-1971

SYNONYMS White Phosphorous, Yellow Phosphorous

COMMON SHIP OR CONTAINER SIZE Under water or blanketed by inert gas in tank cars, tank trucks, cans, or drums

DOT Flammable Solid, Yellow Label, not accepted dry, 25 lb in outside container

USCG Inflammable solid, yellow label

M.P. 44.1 °C

B.P. 280 °C

Sp.G. 1.83

SOLUBILITY 3 mg/l at 25°C

PERSISTENCE

Chemical Hydrolysis, etc.

Reacts rapidly in air to form phosphorous pentoxide which hydrolyzes in water to phosphoric acid

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
0.105	48	Bluegill	TLm		211
0.053	72	Bluegill	TLm		211
0.025	161	Bluegill	TLm		[illegible]

Saltwater Toxicity

0.003	96	Brook Trout	TL_{50}		443

Mammalian

species	mg/kg B. W.	administration route	ref
Rabbit	7	Oral	8

PHOSPHORUS OXYCHLORIDE

Phosphorus oxychloride is a highly reactive compound employed as a chlorinating agent, cryoscopic solvent, and intermediate. The 61,884,000 lbs produced in 1971 (199) were shipped in 1-3 gal glass bottles, lead lined drums, tank cars, and tank trucks.

Phosphorous oxychloride decomposes on contact with water to form hydrochloric and phosphoric acid. Natural dilution will slowly neutralize these contaminants.

While the aquatic toxicity of phosphorous oxychloride is in fact that of the product acids, the oxychloride compound itself can be hazardous. The vapor is extremely irritating to membranes. A concentration of .1 ppm can be damaging (159).

NAME Phosphorous Oxychloride

PRODUCTION QUANTITY 61,884,000 lb 1971 (199)

SYNONYMS Phosphoryl Chloride

COMMON SHIP OR CONTAINER SIZE 1-5 gal glass bottles, lead lined drums, tank cars, tank trucks

DOT Corrosive Liquid-Blue Letters on White Background. 1 qt. outside container

USCG Corrosive liquid, white label

M.P. 1.17 °C

B.P. 107. °C

Sp.G. 1.67

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Hydrolyzes to phosphoric and hydrochloric acids.

TOXICOLOGICAL

Freshwater Toxicity

Refer to phosphoric and hydrochloric acids. HCL will be controlling factor.

Saltwater Toxicity

Refer to phosphoric and hydroch'oric acids. HCL will be controlling factor.

PHOSPHOROUS PENTASULFIDE

Phosphorous pentasulfide is used in the production of matches and as an intermediate and sulfating agent. The 117,000,000 lbs consumed in 1971 (100) were shipped in glass bottles and sealed drums.

Phosphorous pentasulfide decomposes on contact with water to form phosphoric acid and hydrogen sulfide. Considerable offgassing may occur. The effects on aquatic life will be those attributed to the two hydrolysis products.

Phosphorous pentasulfide is a strong irritant, highly toxic when inhaled. A TLV of 1 mg/m^3 has been established. The hydrogen sulfide offgas from hydrolysis may also be toxic and irritating.

NAME Phosphorous Pentasulfide

PRODUCTION QUANTITY 117,500,000 lbs 1971 (199)

SYNONYMS Phosphoric Sulfide, Thiophosphoric Anhydride, Phosphorous Persulfide

COMMON SHIP OR CONTAINER SIZE Glass bottles, sealed drums

M.P. 280. °C

B.P. 513. °C

Sp.G. 2.03

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes in water to phosphoric acid and hydrogen sulfide.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to phosphoric and sulfuric acid. The latter will control.

Salt Water Toxicity

Refer to phosphoric and sulfuric acid. The latter will control.

PHOSPHOROUS TRICHLORIDE

Phosphorous trichloride is used to produce irridescent metallics and phosphorous compounds. The 110,432,000 lbs produced in 1971 (199) were shipped in glass bottles, nickel or lead lined steel drums, and carbon steel tank cars.

Phosphorous trichloride decomposes on contact with water to form phosphoric and hydrochloric acids. The resulting effects on aquatic life will be those attributed to the low pH and the toxicity of the hydrolysis products.

Phosphorus trichloride is a strong irritant, highly toxic when inhaled. A TLV of 3 mg/m^3 has been established.

NAME Phosphorous Trichloride

PRODUCTION QUANTITY 110,432,000 lb 1971 (199)

SYNONYMS Phosphorous Chloride

COMMON SHIP OR CONTAINER SIZE Bottles, carboys, lead or nickel lined steel drums, carbon steel tank cars

DOT Corrosive Liquid, White Label, 1 qt. outside container

USCG Corrosive Liquid, white label

M.P. -112. °C

B.P. 76. °C

Sp.G. 1.574

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes in water to form hydrochloric and phosphoric acid.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to hydrochloric and phosphoric acids. HCl will control.

Salt Water Toxicity

Refer to hydrochloric and phosphoric acids. HCl will control.

POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls, or PCB's, are halogenated aromatics used as transformer coolants, electrical insulating agents, plasticizers, lubricants, epoxy paint additives, fluorescent ballast, and carbonless reproduction paper active ingredients. Production in the U. S. is limited to a single corporation, which produced 40,472,000 lbs in 1971 (199). Imports add additional lbs per year.

PCBs have a low solubility in water. When spilled, they will sink and dissolve at a very slow rate. Like most chlorinated aromatics, PCBs are capable of persisting for great lengths of time at low concentration levels. Some analytical samples have been known to show marked degradation when stored overnight under anaerobic conditions. The discovery of widespread low-level concentrations in all types of waterways in the U. S., however, is believed to indicate an ability to persist over extended periods under normal surface water conditions.

PCBs, like many halogenated organics, are quite toxic to fish. The 96 hr TLm values for trout and bluegill are reported as 1.17-60 and .278 ppm, respectively (160). Salt water species are equally sensitive. Pink shrimp die in water containing .1 ppm after 48 hrs of exposure (160).

Oysters withstand this same concentration for 96 hours, showing a 100 percent decrease in shell growth (160). Portman found shrimp, cockles, and pogge to have an LC50 range of .3--10 ppm (2). The lowest lethal limits reported are .005 ppm for pinfish, spot(161) and juvenile shrimp(163). PCBs are bioaccumulative. Shrimp subjected to 10 ppb for 48 hr accumulated 1300 ppb in their flesh, while oysters accumulated 11,000 ppb over a 96 hr period (160). Toxicity is greatly affected by low levels of common contaminants.

PCBs are strong irritants, toxic when ingested or inhaled. The actual oral toxicity varies with the degree and location of chlorination. The oral LD50 for rats fed Arochlor 1224 is 500-1000 mg/Kg body weight while it is 3000-4000 mg/Kg for the Arochlor 1260 form (165). Similar values for various game bird populations fall in the range 600--5000 mg/Kg body weight (22). Mammals in general show an average oral LD50 of 250 mg/Kg to PCBs. These values can be greatly affected by low levels of common contaminants. Observations of feeding studies include no ill effects on dogs fed 100 ppm in their diet for 3 months (22). A concentration of 3000 ppm Phenochlor DP6 killed coturnix in 55 days (22). Mallards tolerated 3000 ppm of Arochlor 1242, 1254, 1260 and 1268 (22). On the other hand, 500 mg/Kg Arochlor 154 stopped egg laying in coturnix and 1000 mg/Kg did the same to mallards (22).

The major effects of PCBs are from chronic applications. The compound interferes with vitamin D chemistry and causes changes both in egg laying and in the shell thickness of those eggs produced (22). Birds will accumulate PCBs readily in their livers and fatty tissues. Eagles (with 14,000 ppm in their tissue) have been found and peregrine falcons with 2000 ppm (150). The FDA has a set guideline of 5 ppm PCBs in food for human consumption.

Common contaminants in PCBs may increase both acute and chronic hazards. Some types of PCB mixtures may contain tetrachlorodibenzofurans, known teratogens (166).

Polychlorinated biphenyls have been designated toxic substances under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use of determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

NAME Polychlorinated Biphenyls

PRODUCTION QUANTITY 40,472,000 lbs 1971 (199)

SYNONYMS PCB, Polychlorinated Diphenyls, Arochlors

B.P. 340. °C

Sp.G. 1.182-1.492

SOLUBILITY Low solubility - .1-5 ppm

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
1.17-60	96	Trout	TLm		160
.278	96	Bluegill	TLm		160

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
.1	48	Young Pink Shrimp	Lethal		160
.1	96	Oysters	100% Decrease in Shell Growth		160
.3-10	48	Shrimp	LC50	Aerated	2
1-10	48	Cockle	LC50	Aerated	2
>10	48	Prawn	LC50	Aerated	2
.005	336-1080	Pinfish & Spot	TLm		161
0.1		Marine Diatoms	Inhibit Growth		162
.005		Juvenile Shrimp	Killed	Flowing Sea Water	163
2		[illegible] Salmon	Lethal	With Corexit 7664	164

Mammalian

species	mg/kg B. W.	administration route	ref
Rats	500-1000	Oral - arochlor/1254	165
Rats	2000-4000	Oral-arochlor/1268	165
Guinea Pigs	170	Oral LDLo	22

Avian Toxicity

species	mg/kg B. W.	administration route	ref
Mallard	2000-3000	Oral	22
Pheasant	1000-3000	Oral	22
Bobwhite	600-3000	Oral	22
Coturnix	2000->5000	Oral	22

POTASSIUM HYDROXIDE

Potassium hydroxide is employed in electroplating, lithography, painting, textile finishing, organic synthesis, wood treatment (as a mordant), and soap production. The 396,384,000 lbs produced in 1971 (199) were shipped in bottles, boxes, barrels, drums, tank cars, and tank barges.

Because potassium hydroxide is readily soluble in water, when spilled it will soon dissolve and raise the pH of the receiving waters. Natural dilution and carbon dioxide from the atmosphere will slowly neutralize the water.

Potassium hydroxide is toxic to aquatic life. Fish have been killed by concentrations of 28.6-140 ppm (1). The 96 hr TLm for mosquito fish is reported as 80 ppm. Algae are adversely affected when the pH exceeds 8.5. Solution pH, buffer capacity, and hardness are important in determining resulting toxicity.

Potassium hydroxide is a strong irritant, highly toxic when ingested or inhaled. The oral LD50 for rats is reported to be 1230 mg/Kg body weight (77). A dose of 5.6 gm has been fatal to humans (1). The potassium ion concentration should not exceed 1000 ppm in drinking water (7). Similarly, livestock should not be given water with more than 170 ppm potassium hydroxide (7). A TLV of 2 mg/m^3 as a dust has been established. Potassium hydroxide is detectable by taste at 1-50 ppm (1).

NAME Potassium Hydroxide

PRODUCTION QUANTITY 396,384,000 lb 1971 (199)

SYNONYMS Potassium Hydrate, Caustic Potash, Potassia

COMMON SHIP OR CONTAINER SIZE Bottles, boxes, barrels, drums,
tank cars, tank barges

DOT (solution) Corrosive Liquid, White Label, 10 gal. outside
container

USCG Hazardous article

M.P. 360. °C

B.P. 1320. °C

Sp.G. 2.044

SOLUBILITY 970,000 mg/l at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
28.6	24	Minnow	Killed		1
50	24	Trout	Killed		1
56	24	Bluegill	Killed		1
56	4.5	Bluegill	Killed		1
80	24	Mosquito Fish	TLm	Turbid	1
80	96	Mosquito Fish	TLm		1
140	24	Goldfish	Killed		1
150-500	24	Vector Snails	Killed		80

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	1230	Oral	77

POTASSIUM PERMANGANATE

Potassium permanganate is employed for bleaching textiles, producing chemicals, disinfecting, tanning, producing mineral water, chemical analysis, and medicinal purposes. The 5,000,000 estimated lbs produced in 1955 (194) were shipped in bottles, cans, steel drums, and hopper cars.

Potassium permanganate is soluble in water to 63,800 ppm. It is an oxidizing agent which will rapidly attack organics in the receiving water. In a short time the purple permanganate will be reduced to manganese dioxide, a brown precipitate.

Potassium permanganate is toxic to fish in the concentration range 3-62 ppm (1). The 96 hr TLm for bluegill is 4.2 ppm (171), and that for mosquito-fish is 12 ppm (1). Daphnia are immobilized by 0.63 ppm (1). Potassium permanganate has been applied at 0.2-0.5 mg/l for algae control in reservoirs. A level of 4.0 ppm is toxic to blue green algae (171). The permanganate acts as a bactericide, disinfecting waters when applied at low levels. Permanganate will not persist in waters with a high organic content, and hence resulting casualties will be reduced in such an environment. In saltwater the 96 hour estimated LC_{50} to pompano is 2.3 ppm (444).

Potassium permanganate is a strong irritant, highly toxic when ingested or inhaled. The oral LD_{50} for rats is 1090 mg/Kg body weight (172). The subcutaneous value for mice is somewhat lower, 500 mg/Kg (8). Manganese in general should not exceed .05 ppm for drinking water (4). A TLV of 5 mg/m^3 has been established for potassium permanganate dust.

NAME Potassium Permanganate

PRODUCTION QUANTITY 5,000,000 lbs (est.) 1955 (198)

SYNONYMS Chameleon Mineral

COMMON SHIP OR CONTAINER SIZE Bottles, cans, hopper cars, steel drums

USCG Oxidizing material, yellow label

M.P. 240. °C Decomposes

Sp.G. 2.7

SOLUBILITY 63,800 mg/l at 20 °C

PERSISTENCE

Oxygen Demand

Will oxidize organics.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
5		Minute Crustaceans	Death		1
0.63		Daphnia Magna	Immobilized		1
3		Bluegill	Toxic		1
3.2	24	Fingerling Catfish	TLm	Tap	1
4		Large-Mouth Bass	Toxic		1
5		Fathead Minnows	Toxic		1
5.2	24	Bluegill	TLm		1
5.6	24	Bluegill	TLm		1
0.25	24	Trout	Toxic		1
10	12-18	Goldfish	Toxic	Hard	1
11.9	8	Young Eels	Toxic		1
12	24&96	Mosquito-Fish	TLm		1
20-63	.5	Fish	Toxic		1
4.2	24,48,96	Bluegill	TLm	Laboratory	(7)
3.7	96	Creek Chub	TLm	Laboratory	(7)

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	1090	Oral	179
Mice	500	Subcutaneous	6

Saltwater Toxicity

2.3	96	Pompano	Est. LC_{50}	444

PROPIONIC ACID

Propionic acid is used to produce cellulose and fruit flavors, and as a mold inhibitor and topical fungicide. It is produced by a dozen U.S. firms and shipped in carboys, drums, tank cars, and tank barges.

Propionic acid is miscible with water. It will rapidly enter the water when spilled. Natural mineral salts such as calcium propionate are quite soluble (400,000 ppm) and are not likely to precipitate. Natural dilution, however, will slowly neutralize a spill. The dissolved proprionate and proprionic acid, which does not dissociate completely, are biodegradable. As much as .36-1.3 lbs of oxygen can be utilized in the first 5 days (4,14). This should be sufficient to cause localized oxygen deficiencies in a spill situation.

Doudoroff and Katz found that propionic acid would kill fish without lowering the pH below 5 (1). Hence, the undissociated acid is toxic in its own right. The 24 hr TLm for bluegill is reported as 188 ppm (50). The fish food organism Daphnia magna exhibits a 48 hr TLm of 50 ppm (50). A concentration of 250 ppm is toxic to the algae chlorella pyrenoidosa (4).

Propionic acid is an irritant considered to be only slightly toxic when ingested (38). The oral LD_{50} for rats is 4,290 mg/kg body weight (117).

NAME Propionic Acid

SYNONYMS Propanoic Acid, Methylacetic Acid, Ethylformic Acid

COMMON SHIP OR CONTAINER SIZE Carboys, drums, tank cars, tank bar,

M.P. -20.8 °C

B.P. 140.99 °C

Sp.G. 0.993

SOLUBILITY miscible

PERSISTENCE

Oxygen Demand

BOD_{12} = 40% Theo. using phenol acclimated activated sludge-(13)
BOD_5 = .36-.84 lb/lb using sewage seed-(4)
BOD_5 = .96 lb/lb using acclimated seed-(4)
BOD_5 = 1.3 lb/lb-(14)
BOD_{20} = 1.4 lb/lb-(14)
COD = 1.4 lb/lb-(4)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
>1000	48	Culex sp. Larvae	TLm		15
50	48	Daphnia Magna	TLm		22
188	24	Bluegill	TLm		22,
125	24	Daphnia Magna	TLm		173

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	4290	Oral	117

PROPANOIC ANHYDRIDE

Propanoic anhydride is used to produce cellulose, resins, drugs, and dyes. It is produced by three major American firms.

Propanoic anhydride decomposes in water to form propanoic (propionic) acid. In the acid form it is subject to natural neutralization forces and biodegradation. Aquatic toxicity will be that reported for the acid form.

Propanoic anhydride is more toxic than the acid. The oral LD_{50} for rats is 2,360 mg/kg body weight (176). Like the acid, it is an irritant that poses a slight ingestive hazard.

NAME Propanoic Anhydride

SYNONYMS Propionic Anhydride, Methylacetic Anhydride

M.P. -45. °C

B.P. 167. °C

Sp.G. 1.011

SOLUBILITY Decomposes

PERSISTENCE

Oxygen Demand

Refer to Propionic Acid.

Chemical Hydrolysis, etc.

Hydrolyses to propionic acid in water.

TOXICOLOGICAL

Fresh Water Toxicity

Refer to Propionic Acid.

Salt Water Toxicity

Refer to Propionic Acid.

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	2360	Oral	176

PROPYL ALCOHOL

Propyl alcohol, or propanol, is a solvent for resins and cellulose esters. Production reached 60,000,000 lbs in 1969 (199).

Propyl alcohol is miscible with water. When spilled, it will soon dissolve and disperse. The dissolved alcohol is subject to rapid biodegradation. As much as .47-1.5 lbs of oxygen per lb of alcohol can be utilized in the first 5 days (11). This is a sufficiently fast rate to cause localized oxygen slumps in spill situations.

Propyl alcohol is lethal to fish in the 200-500 ppm range (1,199). Goldfish die within 24 hrs when exposed to 500 ppm (1) and a concentration of 11,500 ppm is toxic to the algae chlorella pyrenoidosa (4). Dissolved oxygen deficiencies resulting from BOD will further threaten aquatic life. In saltwater, the 24 hour TLm to brine shrimp is 4200 ppm (478).

Propyl alcohol is a slight ingestive and inhalative hazard (30). The oral LD_{50} for rats has been reported as $1,870^{(8)}$ and $3,300^{(1)}$ mg/kg body weight. Direct contact can lead to mild irritation of eyes and mucous membranes. A TLV of 500 mg/m^3 has been established for propanol vapors.

NAME Propyl Alcohol

PRODUCTION QUANTITY 65,058,000 lb 1969 (199)

SYNONYMS Ethyl Carbinol, Propylic Alcohol, Propanol, Optal

M.P. -127. °C

B.P. 97. °C

Sp.G. 0.804

SOLUBILITY Miscible

PERSISTENCE

Oxygen Demand

BOD_5 = 60% Theo. using treatment plant activated sludge-(5)
BOD_5 = 1.47-1.5 lb/lb-(11)
BOD_5 = 64% Theo. using quiescent activated sludge-(5)
BOD_5 = 76% Theo. with a pure bacterial culture
BOD_5; 10; 15; 20 = 64; 70; 71; 75% Theo. in freshwater (425)
BOD_5; 10; 15; 20 = 61; 66; 67; 75% Theo. in saltwater (425)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	Result	cond	ref
250-500	24	Gudgeon	lethal		1
500	24	Goldfish	Died		1
350-500	24	Creek Chub	lethal	15-21°C	100

Saltwater Toxicity

ppm	hrs	species	Result	cond	ref
4200	24	Brine Shrimp		TLm	425

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	1870	Oral	9
Rat	5400	Oral	9
Mammals	2000-6000	Oral	16

Pyrethrins

Pyrethrins are the name given insecticidal substances found in pyrethrum flowers. When synthesized, they are called pyrethoids. These complex hydrocarbons are used extensively in stock sprays, pet sprays, household sprays, and aerosols. The <1 million lbs produced in 1971 were formulated as concentrated oils and impregnated dusts. Synergists may be added. Recently, 20 percent extract in oil has become a standard in industry.

Pyrethrins are oily yellow liquids insoluble in water. They will sink when spilled and can be moderately persistent. Little is known of their chemistry.

Pyrethrins are moderately toxic to fish. The 96 hour LC_{50} for bluegills is reported to be 74 ppm (451). Similar values have been reported for rainbow trout and channel catfish (451) but Pimentel (88) notes a 48 hour LC_{50} for rainbow trout of 0.054 as well. The difference may be in the formulation. Fish food organisms are also adversely affected by pyrethrins. The 48 hour LC_{50} for Gammarus lacustris and Daphnia pulex are reported as 0.018 and 0.025 ppm respectively (88).

Pyrethrins are widely used because of their relatively low toxicity to mammals and higher forms of life. The oral LD_{50} for rats has been reported as 820-1870 mg/kg body weight, and young mallards has an oral LD_{50} of greater than 10,000 mg/kg body weight (88).

PYRETHRINS

SYNONYMS - Pyrethrin, Pyrethroids, Allethrin, Barthrin, Cyclethrin, Dimethrin, Furethrin, Neopynamin, Phthalthrin, Synthrin, Cinerin, Jasmolin

PRODUCTION - <1,000,000 lbs in 1971

B.P. - 170-200°C

SOLUBILITY - Insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Natural production, moderately persistent.

TOXICOLOGICAL

Freshwater Toxicity

[illegible]	hr	Species	Form	Cond.	Ref.
1.0	5	Guppies	100% Kill		[illegible]
1.5	[illegible]	Carp	100% Kill		[illegible]
54	96	Rainbow trout	LC_{50}		451
[illegible]	96	Channel catfish	LC_{50}		451
74	96	Bluegill	LC_{50}		451
1.0	96	Pteronarcys californica	LC_{50}		451
0.001	96	P. californica Naiads	LC_{50}	Temp 15.5°C	104
[illegible]	[illegible]	Rainbow trout	LC_{50}		[illegible]
[illegible]	[illegible]	P. californica	LC_{50}		[illegible]
[illegible]	[illegible]	Gammarus lacustris	LC_{50}		[illegible]
[illegible]	[illegible]	Gammarus lacustris	LC_{50}		[illegible]
[illegible]	[illegible]	Daphnia pulex	LC_{50}		[illegible]
[illegible]	[illegible]	P. californica	LC_{50}		[illegible]
[illegible]	48	Simocephalus serrulatus	Immobilized		[illegible]
0.025	48	Daphnia pulex	Immobilized		[illegible]

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1200	Oral	[illegible]
Rat	820-1870	Oral	[illegible]
Rat	1500	Oral	[illegible]

Avian Toxicity

Young Mallards	>10,000	Oral	[illegible]

QUINOLINE

Quinoline is used to produce drugs, dyes, paints, varnishes, and various organic chemicals. It is also employed as a solvent for resins and terpenes. Production reached 538,000 lbs in 1969 (198).

Quinoline is a hygroscopic liquid capable of absorbing 22 percent water. It is only slightly soluble in cold water, however. When spilled, it will sink to the bottom and dissolve very slowly to form a weak alkaline solution. It is light sensitive, and in shallow water may darken from photochemical attack. Mineral acids react to form water soluble salts. The dissolved quinoline is also subject to biodegradation. As much as 1.75 lbs of oxygen per lb of quinoline can be utilized in the first 5 days (11). This will be sufficient to cause oxygen slumps in spill situations.

Quinoline is toxic to fish and fish food organisms. Concentrations in the range 5-50 ppm have been lethal to various species of fish (1). Rainbow trout died in 14 hrs when placed in 5 ppm while yearling trout lasted 1 hr in 7.5 ppm (1). The toxic threshold for the fish food organisms Daphnia and

Microregma have been reported as 52 and 50 ppm respectively. Scenedesmus tolerate up to 160 ppm (1). Aquatic life may also suffer from low dissolved oxygen resulting from the high BOD of quinoline solutions. Undissolved layers may destroy benthic life forms. Quinoline has been reported to affect the taste of carp flesh when present in rearing water at 0.5-1.0 ppm (1).

Quinoline is highly toxic when ingested or inhaled. The oral LD_{50} for rats is 460 mg/kg body weight (8). Quinoline can produce detectable tastes in water in the .015-4.3 ppm concentration range. (30)

NAME Quinoline

PRODUCTION QUANTITY 538,000 lb 1969 (188)

SYNONYMS 1-Benzazine, Benzo[b] pyridine, Chinoleine, Chinoline, Leucol, Leucoline, Leukol

M.P. -15. °C

B.P. 237.7 °C

Sp.G. 1.09

SOLUBILITY 60,000 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

BOD_5 = 1.75 lb/lb using sewage seed (11)

Chemical Hydrolysis, etc.

Darkens when exposed to light.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	harm	cond	ref
5	14	Rainbow Trout	Lethal	13°C	1
5	4	Bluegill	Lethal	13°C	1
5	4	Sea Lamprey	Caused Illness	13°C	1
7.5		Fish	Lethal		1
7.5-1	1	Yearling Trout	Lethal	13°C	1
10		Bleak, Bream, carp	Toxic Threshold		1
<30		Perch	Lethal		1
50		Perch	Lethal		1
60		Microregma	Toxic Threshold	23°C	1
52		Daphnia	Toxic Threshold	24°C	1
140		Scenedesmus	Toxic Threshold	24°C	1
800		E. Coli	Toxic Threshold	27°C	1
750		Ciliates	Toxic		1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	460	Oral	8

RESORCINOL

Resorcinol is employed in veterinary medicine, textile processing, dye manufacture, adhesive production, explosive production, tanning, and chemical analysis. It is produced by eight American firms and shipped in polyethylene or aluminum lined fiber drums with a 25-30 lb capacity.

Resorcinol is quite soluble in water, rapidly dispersing through the receiving water when spilled. Resorcinol begins to decompose on exposure to light and air. However, it does not form the dark quinone compounds as the hydroquinones do because of the meta configuration of the hydroxy groups. The decomposing solid goes from white to pink. The dissolved resorcinol is subject to biological attack. As much as 1.18 lbs of oxygen per lb of resorcinol can be utilized in the first five days (11). Acclimation can accelerate this rate. Localized oxygen slumps will be evidenced in spill situations.

Resorcinol, like most phenolics, is toxic to aquatic life. The toxic threshold for bleak and carp is 15 ppm (1). Fish food organisms are affected in the range of 0.8-60 ppm (1,175). Phenols in general should be kept below 1 ppm in freshwater and 5 ppm in saltwater to sustain healthy fish populations (41). Resorcinol can influence the taste of fish flesh if present in rearing waters at a concentration of 30 ppm (1).

Resorcinol, like most phenols, can be toxic via all routes of administration. The oral LD50 for rats has been reported as 980 mg/kg body weight (170). Phenols in general should not exceed .001 ppm for drinking water (1). This, however, is based upon taste thresholds when chlorinated, and not toxicity. Resorcinol is detectable by smell when present at 40 ppm (1). Waterfowl may be harmed if phenol concentrations exceed 25 ppm (41).

Resorcinol can be absorbed through the skin at toxic levels. Phenols should not exceed 50 ppm in freshwater or 1 ppm in saltwater used for swimming purposes (61). Solutions of greater than 10 percent can be irritating on contact.

NAME Resorcinol

SYNONYMS 1,3-Benzendiol, 1,3-Dihydroxybenzene, Resorcin

COMMON SHIP OR CONTAINER SIZE Fiber drums with polyethylene or
aluminum lining, 25-300 lbs

M.P. 110. °C

B.P. 280. °C

Sp.G. 1.27

SOLUBILITY 1,000,000 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

BOD$_5$ = 32% Theo. with phenol acclimated activated sludge-(10)
BOD$_5$ = 39% Theo. with catechol acclimated activated sludge-(10)
BOD$_5$ = 0.59 Theo. with phenol acclimated seed-(5)
BOD$_5$ = 1.15 lb/lb with sewage seed-(11)
BOD$_5$ = 61% Theo.-(166)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	para	cond	ref
35		Bleak & Carp	Toxic Threshold		1
0.8	48	Daphnia	Toxic Threshold	23°C	1
60	96	Scenedesmus	Toxic Threshold	24°C	1
40		Microregma	Toxic Threshold	24°C	1
1000		E. Coli	No Effect	27°C	1
56.4	48	Daphnia	Killed		175

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	450	Subcutaneous - MLD	8
Rat	980	Oral	170

SELENIUM

Selenium is a metal commonly obtained as a by-product from copper mining operations. In salt forms it is used to make glass, electrodes, rubber, duplication equipment, dyes, and photographic developing solutions. Approximately 86 tons of selenium are produced in the U. S. each year[287]. The metal and salts are shipped as containerized solids.

Selenium in the metallic form is insoluble. Most selenium salts, however, are readily soluble and will dissolve if spilled in water. Many industrial operators have found it exceedingly difficult to reduce selenium concentrations in effluents below acceptable levels. The selenide, selenate, and selenite anionic species can be quite persistent in natural waters. They can potentially undergo complex chemical-biological interactions which will cycle them through the water and bottom sediments.

Selenium is toxic to fish and fish food organisms. Sodium selenite at 2 ppm is toxic to goldfish over a 192 hr period (1). Daphnia and Scenedesmus are affected by concentrations as low as 2.5 ppm while microregma have a 96 hr TLm of 183 ppm (1). Selenium appears to be bioconcentrative. Fish deaths in a Colorado reservoir have been attributed to food chain concentration of selenium from bottom deposits(1).

Selenium is toxic when ingested or inhaled. Various species of livestock die when fed selenium at levels of 1.5-6 mg/kg body weight (1). Selenium poisoning often occurs in nature from ingestion of forage containing as little as 1 mg/Kg (1). Humans have been killed by ingestion of a 4 mg dose (208). Drinking water levels should not exceed .01 ppm for humans (1) or livestock (48). Chronic poisoning is more probable than acute poisoning. Administration of 3 mg/l Se^{+4} and Se^{+6} in water to mice and rats gave a positive carcinogenic response (56). Doses of 8 Mg/Kg body weight produced abnormalities in young turkeys (1).

Selenium poses a special threat when present in irrigation water because of plants' ability to accumulate the metal. Wheat has been found to contain as much as 63 mg/Kg and onions 17.8 mg/Kg(1). Byers contends that soil containing 0.5 mg/Kg and/or plants containing 5 mg/Kg pose a major threat to livestock (1). The selenium is also directly toxic to plants. Water with more than 0.5 ppm selenium is unusable for irrigation purposes (1).

NAME Selenium

PRODUCTION QUANTITY 80 tons (1971) 807

SYNONYMS Red Selenium

M.P. 217 °C

B.P. 684.9 °C

Sp.G. 4.81

SOLUBILITY Insoluble

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	DATA	COND	REF
2	192	Goldfish	Toxic	Sodium Selenite	1
2.5	48	Daphnia	Threshold Effect	23 °C	1
2.5	96	Scenedesmus	TLm	24 °C	1
92	96	E. Coli	TLm	24 °C	1
183	96	Microregma	TLm	27 °C	1

Mammalian

species	mg/kg B.W.	administration route	ref
Dog	2	Oral-fatal	1
Cattle	2 mg/lb	Oral-fatal	1
Horse	3.3	Oral-MLD	1
Cows & Calves	4.5-5.0	Oral-MLD	1
Pigs	6-8	Oral-MLD	1
Rabbits	2-6	Oral LD_{100} of Salts	1

SELENIUM OXIDE

SYNONYMS - Selenium Dioxide, Selenious Anhydride

M.P. 340°C

B.P. - Sublimes at 315°C

Sp. G. - 3.954

SOLUBILITY - 384,000 ppm @ 14°C

PERSISTENCE

Chemical Hydrolysis, etc. - Forms selenious acid upon dissolution in water which only partially dissociates at normal pH range leaving bulk of molecules in the $HSeO_3^-$ form. Depresses the pH. May be oxidized to selenate form by presence of carbon or organic materials.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
[illegible]	[illegible]	[illegible]	No Harm [illegible]	Stabilized Tap Water	[illegible]

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rabbit	4	Subcutaneous	99
Rat	7 as Selenious Acid	Oral	98

SODIUM SELENITE

Sodium selenite is used in glass production. It is presently marketed by seven major U.S. firms.

Sodium selenite is freely soluble in water as are most stable forms of ionized selenium. When spilled, the salt will quickly disperse through the water column and may persist there indefinitely.

Sodium selenite is toxic to fish and fish food organisms at low levels. Goldfish have been killed in hard water containing 10 ppm (1). A concentration of 100 ppm brought death in 18 hrs (1). Fish food organisms such as Daphnia and Scenedesmus are experienced at a toxic threshold at 2.5 ppm (1). Selenium may be concentrated through the food chain. Incidences of human poisoning after consumption of seleniferous plant fed livestock have been reported (127).

Sodium selenite is an irritant and can be toxic when ingested or inhaled as a dust. The oral LD50 for rats is reported at 13 mg/Kg body weight (201). A lethal dose of .4 mg/Kg has also been found (8). Farmstead livestock display oral MLD values of 1.5-8 mg/Kg body weight (1). Rats fed more than 6.4 ppm in their diet had slow growth, and 8 ppm was fatal by the fourth week. Water for human consumption should not exceed .01 ppm selenium (56). Sodium selenate can be absorbed through skin at chronically toxic rates (38).

NAME Sodium Selenite

SOLUBILITY Freely Soluble

TOXICOLOGICAL

Fresh Water Toxicity

PPM	HRS	SPECIES	DATA	WATER	REF
10	90-100	Goldfish	Toxic	Hard	1
10	72-96	Goldfish	Toxic	Soft	1
100	12-15.5	Goldfish	Toxic	Hard	1
2.5	48	Daphnia	Toxic Threshold	River Havel	1
2.5	96	Scenedesmus	Toxic Threshold	River Havel	4
90	-	E. Coli	Toxic Threshold	River Havel	4
183	-	Microregma	Toxic Threshold	River Havel	4
55	96	Fathead Minnow Sat. LC_{50}			447

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	4	Oral-LD_{100}	2
Rat	3	Intravenous	2
Rabbits	1.5	Oral-MLD	[illegible]
Horses	1.5	Oral-MLD	[illegible]
Cows	4.5-5.0	Oral-MLD	[illegible]
Pigs	6-8	Oral-MLD	[illegible]
Rat	7	Oral	101
Mice	7	Oral	102
Rabbit	2.25	Oral	103
Rabbit	4	Oral-LD_{100}	53
RAT	4	Oral	53

CFM-

SODIUM

Sodium metal is employed in the manufacture of sodium salts, tetraethyl lead, sodium lamps, and photoelectric cells. The 306,180,000 lbs produced in 1971 (190) were shipped in hermetically sealed steel drums, tin cans, and tank cars.

Sodium decomposes violently upon contact with water to form sodium hydroxide which is slowly neutralized to a variety of soluble sodium salts (e.g. chloride, carbonates, sulfates, phosphates, nitrates, etc.) by natural dilution.

In a spill situation, the initial aquatic effects will be those attributed to sodium hydroxide. The high pH destroys many forms of aquatic life. Algae is adversely affected at pH levels above 8.5, as are most fish (1). Sodium ions at a concentration of 4720 ppm were not harmful to stickleback. The 48 hr TLm for marine fish is reported as 24,000-35,000 ppm sodium ion (109).

While the most significant data concerning the effects of a sodium spill will be those of sodium hydroxide, sodium ions in general can be hazardous. Sodium in drinking water may be harmful to persons suffering from cardiac, renal, and circulation disorders. Levels of 200 mg/l may be injurious. Hubbard recommends a desirable limitation of 10 mg/l (1). Sodium salts can be tasted in water at various levels. The carbonate has a taste threshold of 34 ppm, the chloride and acetate 135 ppm, and the bicarbonate 500 ppm (1). Water for livestock use should not contain more than 1000-2000 ppm (11). A level of 22 ppm can be injurious to citrus plants when used for irrigation.

Excessive amounts of dissolved sodium in irrigation or other waters can disperse soils. The additional sodium destroys the calcium balance and renders soil impermeable to water.

NAME Sodium

PRODUCTION QUANTITY 306,150,000 lbs 1971 (199)

SYNONYMS Natrium

COMMON SHIP OR CONTAINER SIZE Hermetically sealed steel drums, tin cans, tank cars

M.P. 97.8 °C

B.P. 889. °C

Sp.G. .9710

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Violently decomposes to sodium hydroxide upon contact with water.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	harm	cond	ref
as sodium ion					
4730		Stickleback	Harmless	Distilled Water	1

Refer to sodium hydroxide

Salt Water Toxicity

as sodium ion					
24,000- 26,000	48	Marine Fish	Tlm	Salt Water	107

Refer to sodium hydroxide

SODIUM BISULFITE

Sodium bisulfite is employed in food preserving, wool bleaching, fermentation, pulp and paper production, synthetic rubber production, chemical manufacture, laundering, and disinfecting. It is presently offered by numerous American suppliers.

Sodium bisulfite is soluble in water, forming a weakly acidic solution. As the pH moves above 4 the sulfite is converted to sulfate. Hence, natural dilution will quickly transform sodium bisulfite to the more stable sodium sulfate salt.

Sodium bisulfite is relatively toxic to fish and fish food organisms. The minimum lethal dose for minnows is 60-65 ppm in hard water (1). The 96 hr TLm for mosquito fish in turbid water is 240 ppm (1). Daphnia are affected in the range 60-115 ppm depending on dissolved oxygen levels (1,59). Toxic thresholds are lowered with the presence of other sodium salts (1). Water hardness and solution pH will also be important in determining resulting toxicity.

Sulfites are moderately toxic when inhaled or ingested (38). The intravenous LD50 for rats is reported to be 115 mg/Kg body weight (8). Concentrated solutions are irritating to skin and mucous membranes.

NAME Sodium Bisulfite

SYNONYMS Sodium Acid Sulfite, Sodium Hydrogen Sulfite

Sp.G. 1.48

SOLUBILITY 300,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, etc.

Converts to sulfate above pH 4.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	result	cond	ref
102	100	Daphnia Magna	Toxic Threshold	23°C	1
109		Daphnia Magna	Toxic Threshold	9.3 mg/l O_2	1
81		Daphnia Magna	Toxic Threshold	6.5 mg/l O_2	1
77		Daphnia Magna	Toxic Threshold	3.2 mg/l O_2	1
70		Daphnia Magna	Toxic Threshold	1.6 mg/l O_2	1
60-65	6	Minnows	MLD	Distilled, 18°C	1
80-85	6	Minnows	MLD	Hard, 18°C	1
240	24,48,96	Mosquito Fish	TLm	Turbid, 17-22°C	1
116	48	Young Daphnia Magna	TLm		59
102	96	Adult Daphnia Magna	TLm		59
179	96	Dugesia sp	TLm		59

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	115	Intravenous	8

SODIUM HYDROSULFIDE

Sodium hydrosulfide is employed in a variety of applications. The 59,000,000 lbs produced in 1971 were used in dehairing hides, desulfurizing viscose rayon, and manufacturing sulfur containing dyes, and other thio compounds.

Sodium hydrosulfide is a white or colorless crystal freely soluble in water. It is quickly hydrolyzed in moist air to sodium hydroxide and sodium sulfide. The salt turns yellow upon heating in dry air. Upon spillage, dilution will neutralize the alkalinity produced while some of the sulfide will be precipitated as metal salts. If acid conditions prevail, hydrogen sulfide gas will be evolved. Under alkaline conditions, the sulfide will slowly be oxidized to thiosulfate.

Sodium hydrosulfide has been found to be toxic to aquatic life. The minimum lethal concentration for king salmon, silver salmon, and cutthroat trout are reported as 1.3 ppm, 1.5 ppm, and 1.0 ppm respectively.[1] Turbidity appears to reduce the toxicity. Wallen, et al.,[58] found the 96 hour TLm for mosquito fish in turbid water to be 206 ppm.

Sodium hydrosulfide can release toxic hydrogen sulfide gas. The intravenous LD_{50} to rats is reported as 115 mg/kg body weight (86).

SODIUM HYDROSULFIDE

SYNONYMS - Sodium Sulfhydrate, Sodium Bisulfide, Sodium Hydrogen Sulfide

PRODUCTION QUANTITY - 50,000,000 lbs - 1971

M.P. 350°C

Sp. G. = 1.79

SOLUBILITY - Freely soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Readily hydrolyzed in moist air to NaOH and Na_2S.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
206	24, 48, 96	Mosquito Fish	TL_m	Turbid	1
138	144	Mosquito Fish	TL_m	Turbid	1
1.3	-	King Salmon	MLD		1
2.1	-	King Salmon	Max. Tolerated		1
1.5	-	Silver Salmon	MLD		1
2.5	-	Silver Salmon	Max. Tolerated		1
1.0	-	Cutthroat Trout	MLD		1
0.3	-	Cutthroat Trout	Max. Tolerated		1
0.5	-	Wisconsin Minnows	MLD		1
4-10	-	Creek Chub	Critical Range		1
0.3-2.5	-	Salmonids	Damage Threshold - 5 ppm 0% lethality		1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	115	Intravenous	96

SODIUM HYDROXIDE

Sodium hydroxide is used in the production of celluloses, rubber, paper, rayon, and numerous chemical compounds. It is also a common waste constituent of fly ash slurries, dye and ink plants, petroleum refineries, tanneries, soap manufacturers, and food processors. The 19.3 billion lbs produced in 1971 (199) were shipped dry and in solution in bottles, cans, drums, tank cars, and tank barges.

Sodium hydroxide is soluble in water and will soon dissolve after spillage. The compound quickly dissociates putting great upward pressure on solution pH. When initial concentrations are high, various dissolved metals, calcium, and magnesium may be precipitated out as hydrous oxides. These will redissolve with dilution. Natural dilution and buffer capacity will slowly neutralize spills.

Sodium hydroxide, while not inherently toxic, is hazardous to aquatic life because of its ability to raise pH. Toxicity is generally exhibited well above pH 9. The lethal limit for bluegill is reported as pH 10.5 while that for goldfish is 10.9 (1). Toxic action on various species has occurred at concentrations of 20-100 ppm (1). The 48 hr TLm for bluegill is reported as 99 ppm in tap water (1). Fish food organisms like Daphnia are killed in the range 40-240 ppm(1). In seawater, oysters have been destroyed at 50-100 ppm (1) while shrimp, pogge, and starfish exhibit an LC50 of 33-100 ppm (2). Solution pH, buffer capacity, and alkalinity will be important in determining resulting toxicity.

Sodium hydroxide can be highly toxic when ingested or inhaled. The oral LD50 for rabbits administered a 10 percent solution was 500 mg/kg body weight (8). A dose of 1.95 gms can be fatal to humans (1). Rats given 5000 mg/l in drinking water showed no effects, while 10,000 mg/l caused nervousness, sore eyes, diarrhea, and retarded growth(1). Sodium hydroxide is also a strong irritant.

The taste threshold range for sodium hydroxide is 1-50 ppm (1).

NAME Sodium Hydroxide

PRODUCTION QUANTITY 10.3 billion lbs-1971

SYNONYMS Caustic Soda, Sodium Hydrate, Soda Ash

COMMON SHIP OR CONTAINER SIZE Bottles, cans, drums, tank cars,
tank barges

DOT (Solution) Corrosive Liquid, White Label, 10 gal in
outside container

USCG Hazardous Material, (solution) corrosive liquid, white label

M.P. 318 °C

B.P. 1390 °C

Sp.G. 2.13

SOLUBILITY 420,000 mg/l at 0 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
150-450	24	Vector Snails	Lethal	27°C	80
100		Daphnia	Lethal		1
100		Minnows	Lethal		1
40-240		Daphnia Magna	Toxicity Threshold		1
125-1000		Various Insect Larvae	Lethal		1
200	10	Roach, Perch	Loss Equilibrium		1
400		Water Beetles	Stimulate Movement		1
20		Silver Salmon	Killed		1
25	24	Brook Trout	Killed		1
35		Cutthroat Trout	Killed		1
40	24	Creek Chub	Killed	Fresh	1
48		King Salmon	Killed		1
70	5	Fish, Crabs	Killed	Stagnant	1
71.5		Carp, Shiners, Suckers	Killed		1
90	4.5	Fish, Oysters	Killed	Circulating	1
96	2-10 min.	Carp, Shiners	Killed	Tap	1
99	48	Bluegill Sunfish	TLm	Tap	1

ppm	hrs	species	param	cond	ref
100		Minnows	Killed		1
100		Fish	Killed		1
100	120	Shiners	Killed		1
100	3-20	Goldfish,Bass	Killed		1
125	96	Mosquito Fish	TLm	Turbid	1
100(pH12)	23	Fish,Oysters	Killed	Circulating	1
10		Cutthroat Trout	Safe		1
11		Silver Salmon	Safe		1
20	24	Creek Chub	Safe	Fresh	1
27		King Salmon	Safe		1
50	2	Perch,Roach	Safe	Distilled	1
50	7 days	Goldfish,Bass	Safe		1
55.5		Carp,Shiners, Suckers	Safe		1
200	5	Some Fish	Safe		1

Salt Water Toxicity

90	4.5	Oysters	Lethal	Circulating	1
100	21	Oysters	Lethal	Circulating	1
33-100	48	Shrimp	LC50	Aerated	2
330-1000	48	Cockle	LC50	Aerated	2
33-100	48	Pogge	LC50	Aerated	2
33-100	48	Starfish	LC50	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Rabbits	500	Oral-10% Solution	3

SODIUM HYPOCHLORITE

Sodium hypochlorite is a bleaching solution used for cleaning and disinfecting.

Sodium hypochlorite exists only in solution. When spilled, it will rapidly disperse through the water column. Sodium hypochlorite gives a strongly basic solution in water due to the formation of weak hypochlorous acid. The hypochlorite ion is a strong oxidizing agent and will attack organics in natural waters leaving a chloride byproduct.

Hypochlorite can be extremely toxic to fish. Data pertinent to effects on aquatic life can be found with information on chlorine and calcium hypochlorite. In general, calcium hypochlorite at 0.5-10 ppm will kill trout and other fish (1).

Hypochlorite solutions are highly corrosive to mucous membranes. Prolonged contact with skin may also be irritating. They are also quite toxic when ingested. The oral LD50 for rats has been reported as .12 mg/kg body weight (333).

NAME Sodium Hypochlorite

SYNONYMS Clorox, Eau de Javelle, Dazzle

COMMON SHIP OR CONTAINER SIZE Glass Carboys, Drums

SOLUBILITY Freely soluble

TOXICOLOGICAL

Fresh Water Toxicity

Refer to Chlorine.

Salt Water Toxicity

Refer to chlorine.

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	12	Oral	[illegible]

SODIUM METHYLATE

Sodium methylate is employed in organic synthesis. It is presently marketed by six American suppliers.

Sodium methylate decomposes in water to form sodium hydroxide and methanol. The hydroxide will be neutralized with natural dilution; the methanol is biodegradable.

Aquatic toxicity and concentrations of concern will be those for the sodium hydroxide and methanol produced. No toxicity data are available on the pure material.

NAME Sodium Methylate

SYNONYMS Sodium Methoxide

DOT (alcohol solution) Flammable Liquid, Red Label, 10 gal outside container

(dry) Flammable Solid, Yellow Label, 100 lbs outside container

Sp.G. [illegible].50

SOLUBILITY Decomposes

TOXICOLOGICAL

Fresh Water Toxicity

Refer to sodium hydroxide.

Salt Water Toxicity

Refer to sodium hydroxide.

[illegible]

SODIUM NITRITE

Sodium nitrite is consumed in dye production, textile processing, photography, meat preparation, and chemical production operations. It is presently marketed by more than a dozen American firms.

Sodium nitrite is highly soluble and dissociated completely in water. It forms an alkaline solution as some of the nitrite combines with hydrogen ions to form undissociated nitrous acid. In aerobic conditions nitrite ions are soon oxidized to nitrates.

Sodium nitrite can be toxic to aquatic organisms. While 17.1 mg/l had no effect on minnows during a 24 hr period, 50 mg/l was fatal in 14 days (1). The 96 hr TLm for mosquito fish in turbid water is 7.5 ppm (1). The critical range for creek chub is [illegible]0-2000 ppm (54). Daphnia are immobilized at levels below 100 ppm (1). Scenedesmus, however, were not affected at 1500 ppm (1). Degree of aeration and dissolved oxygen content will be important in determining toxicity. Nitrities can act as nitrogen sources for algae and other aquatic lif

Sodium nitrite is highly toxic when ingested or inhaled. The oral LD_{50} for rates is reported to be 180 mg/kg body weight (77). The estimated LD_{50} for humans is 20 mg/kg body weight for nitrite ions (56). Water for consumption should not exceed 100 ppm (127). Rats fed 60 mg/kg had increased fatal mortality and spontaneous abortions (186). Concentrations of 50-200 ppm in drinking water slows growth in chickens. Water for livestock in general should not contain nitrite (41). Chronic application of 300 and 450 mg/kg body weight in rat's drinking water for 56 days led to decreased weight gain and increased methemoglobin levels (56).

SODIUM NITRITE

SYNONYMS - Erinitrit

M.P. 271°C

B.P. 320°C

Sp. G. = 2.17

SOLUBILITY = 815,000 at 15°C

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Efct	Cond	Ref
17.1	24	Minnows	No Effect		1
50	14 days	Minnows	Fatal		1
10,000	1.5	Minnows	Fatal		1
8.1	24	Mosquito-Fish	TLm	Turbid, 21-24°C	1
7.5	48,96	Mosquito-Fish	TLm	Turbid 21-24°C	1
42		Polycelis Nigra	Toxic Threshold		1
<26		Daphnia	Immobilized	Lake Erie	1
23		Daphnia	Immobilized	River Havel	1
194		E. Coli	Toxic Threshold	River Havel	1
1500		Scenedesmus	Harmless	River Havel	1
400-2000	24	Creek Chub	Critical Range	Detroit River	54

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref
Dog	330	Oral-MLD	1
Rat	180	Oral	77
Rat	15	Subcutaneous	176
Human	30	Oral-Nitrite ion	56

SODIUM PHOSPHATE

Sodium phosphate is employed in soldering, ceramics, fireproofing, cheese manufacture, paper production, leather tanning, and detergent manufacture. Consumption reached 2,589,160,000 lbs in 1971 (199).

Sodium phosphate can be handled in many distinct forms including monobasic ($NaH_2PO_4 \cdot H_2O$), dibasic ($Na_2HPO_4 \cdot 7H_2$), tribasic ($Na_3PO_4 \cdot 12H_2O$), tetrasodium pyrophosphate ($Na_4P_2O_7 \cdot 10H_2O$), sodium hexametaphosphate ($(NaPO_3)_6$), and sodium tripolyphosphate ($Na_5P_3O_{10}$). All are relatively soluble and will be found in solution following spills into water. Each form produces a characteristic pH when dissolved; all forms buffer the water to a great extent. All forms are relatively stable chemically. Iron, calcium, aluminum, and magnesium are all capable of precipitating phosphates out of solution, but the kinetics are generally slow so that supersaturated calcium phosphate may exist for an extended period. Phosphates can also be utilized by bacteria. Typically, bacteria first break down the pyro- and polyphosphates to the orthophosphate forms. Then the orthophosphates are consumed as nutrients.

The toxicity of sodium phosphates varies with the chemical form. The 96 hr TLm values for Daphnia magna exposed to monobasic and tribasic sodium phosphates are 426 ppm and 126 ppm, respectively (59). In general, toxicity increases as hydrogen is replaced by sodium. Similarly the 96 hr TLM values for mosquito-fish exposed to monobasic and tribasic salts are 720 ppm and 151 ppm, respectively (1). The 96 hr TLm for fathead minnows in sodium tripolyphosphate is 400 ppm (189). Solution pH and hardness will be critical parameters in determining toxicity resulting from spills.

Sodium phosphates are not considered highly toxic. The intraperitoneal LD50 for rats is reported to be 430 mg/kg body weight (190). Large internal doses can cause purging. Contact can lead to irritation of skin and mucous membranes.

Other aquatic concentrations of interest include a taste threshold of 200 ppm for Calgon and 225 ppm for tribasic phosphate (1). Water for livestock should not contain more than 1000-2000 ppm sodium (41).

NAME Sodium Phosphate

PRODUCTION QUANTITY 2,589,360,000 lb (1971) (199)

SYNONYMS Phosphate of Soda, DSP, Exsiccated Sodium Phosphate
Mono, Di, and Tri basic forms.

Sp.G. 2.04, 1.52, 1.645 (mono, di, and tribasic)

SOLUBILITY 599,000, 41,500, and 15,000 ppm (mono, di, and tribasic)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
1154	24	Daphnia Magna	TLm	Mono Acid	59
1089	48	Daphnia Magna	TLm	Mono Acid	59
426	96	Daphnia Magna	TLm	Mono Acid	59
217	24	Daphnia Magna	TLm	Tribasic	59
177	48	Daphnia Magna	TLm	Tribasic	59
126	96	Daphnia Magna	TLm	Tribasic	59
1560		Daphnia Magna	Immobilized	Monobasic	1
<59		Daphnia Magna	Immobilized	Dibasic	187
<52		Daphnia Migna	Immobilized	Tribasic	187
.026M	48	Polycelis Nigra	Lethal	pH 6.6	188
400	24-96	Fathead Minnow	TLm	Tripoly	189
720	24-96	Mosquito Fish	TLm	Monobasic	1
1380	24-96	Mosquito Fish	TLm	Tetrasodium Pyro	1
467	24,48	Mosquito Fish	TLm	Tribasic	1
151	96	Mosquito Fish	TLm	Tribasic	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	410	Intraperitoneal - Tribasic	190
Mouse	875	Subcutaneous - Hexasodium Tetrapolyphosate	96
Rat	2000	Intraperitoneal - Dibasic	96

SODIUM SULFIDE

Sodium sulfide is employed in tanning, dyeing, wool treating, metal refining, ore floatation, engraving, cotton printing and chemical manufacture. The 148 million lbs produced in 1969 (198) were largely shipped in glass bottles, cans and steel drums.

Sodium sulfide is quite soluble in water. When spilled it will sink and disperse, forming an alkaline solution. The rise in pH is due to the formation of hydrogen sulfide. Strong buffer capacity or acid conditions will accelerate the production of this toxic gas. When neutral or alkaline, these solutions oxidise to thiosulfate or hydroxide upon standing. The pure salt discolors to yellow, then brown when left exposed. Heavy metal sulfides are quite insoluble and precipitate out if metal cations are available.

Sodium sulfide is very toxic to aquatic life because of its propensity to form hydrogen sulfide. The maximum safe concentrations for king salmon, silver salmon, and cutthroat trout have been reported as 1.8, 1.1, and 1.0 ppm, respectively.(1) The 48 hr TLm for bluegill is 61 ppm (1). Lethal concentrations have been reported in the range of 0.55 ppm for young carp to a 96 hr TLm of 750 for mosquito fish in turbid water(1). Fish food organisms are killed in the concentration range 1-97 ppm (1). Toxicity is highly dependent on solution pH and alkalinity. One study has shown the critical toxic level to rise by a factor of 15 with a rise in pH from 5.2 to 6.2 (1). In general, sulfide concentrations should not exceed .5 ppm for fresh or saltwater fishes (41). Fish will avoid waters containing 3.1-39 ppm (1).

Sodium sulfide is quite toxic when ingested. The intravenous LD50 for rabbits has been recorded at 6 mg/kg body weight (8). The salt also has irritant properties.

Other aquatic concentrations of interest include a maximum level of 1000-2000 ppm sodium for livestock drinking water (41) and a chronic aquatic toxicity level of 1 ppm (42).

NAME Sodium Sulfide

PRODUCTION QUANTITY 148 million lbs. (1969)

SYNONYMS Sodium Sulfuret

COMMON SHIP OR CONTAINER SIZE Glass bottles, cans, steel drums

DOT Flammable solid, Yellow Label, 300 lbs. in an outside container

USCG Inflammable solid, Yellow Label

M.P. 920 °C decomposes

Sp.G. 1.856

SOLUBILITY 475,000 mg/l at 25 °C

PERSISTENCE

Chemical Hydrolysis, Etc.

Oxidizes in neutral or alkaline solutions upon standing.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
10		Daphnia	Lethal		1
2-1000		Insect Larvae	Lethal		1
4.55		Stickleback	Lethal		145
15		S. Trutta	Lethal		145
1.8		King Salmon	Max. Safe Con.	17.5 °C	1
1.1		Silver Salmon	Max. Safe Con.	15 °C	1
1.0		Cutthroat	Max. Safe Con.	12 °C	1
0.55		Young Carp	Lethal	pH 5.2	1
1.0		Salmonoid Fish	Lethal	Aerated	1
1.8		Salmonoid Fish	Lethal	Aerated	1
2.0		Minnows	Lethal	Distilled	1
2.4		Brown Trout	Lethal		1
3.0		Minnows	Lethal		1
3.0		Cutthroat Trout	Lethal	12 °C	1
3.0		Shiners, Minnows	Lethal		1
3.1		Silver Salmon	Lethal	15 °C	1
3.2	48	Fathead Minnows	Lethal		1

ppm	hrs	species	parm	cond	ref
3.3		Young Carp	Lethal	pH 7.4	1
3.6		King Salmon	Lethal	17.5 °C	1
7.0	1.5	Minnows	Lethal		1
10-11	6	Minnows	Lethal	Hard, 15 °C	1
11		Stickleback	Lethal		1
12-13	6	Minnows	Lethal	Distilled 25 °C	1
30	.1	Minnows	Lethal		1
50		Minnows	Lethal	Hard	1
61	48	Bluegill Sun-Fish	TLm	Standard	1
750	96	Mosquito fish	TLm	Turbid	1
1-2		Mayfly Larvae	Killed		1
2-1000		Insect Larvae	Killed		1
2.44		Bivalve Larvae	Lethal		1
3.2		Mesocyclops Leuckarti	Toxic Threshold		1
9.4-10		Daphnia Magna	Killed or Immobilized		1
10	48	Daphnia Magna	MLD	17 °C	1
34		Polycelis Nigra	Toxic Threshold		1
63		Daphnia	Toxic Threshold		1
97		Scenedesmus	Toxic Threshold		1
220		E. Coli	Toxic Threshold		1
1000		Chironomus Larvae	Resisted		1

Mammalian

species	mg/kg B.W.	administration route	ref
Rabbit	6	Intravenous	8
Mice	51	Intraperitoneal	100

Strychnine

Strychnine is a natural extract from nux vomica seeds. It is a poisonous alkaloid used as a rodenticide in baits usually dosed at 0.5-1 percent of the sulfate.

Strychnine is a white crystalline powder soluble to 160 ppm. No water chemistry data is available, but salts forming with common anions in water may be moderately persistent. No fish toxicity data is available, but Baldridge (452) has determined that 1.7 ppm in water can incapacitate lemon sharks in 10 minutes.

Strychnine is an ingestive poison for vertebrates. A dose of 30-60 mg/kg can be fatal when ingested by man. The oral LD_{50} for rats is reported as 5 mg/kg body weight (8). The mule deer is similarly affected by 20 mg/kg body weight (165). Strychnine can also be toxic when inhaled. The TLV has been established as 0.15 mg/m^3 (18).

STRYCHNINE

SYNONYMS - Strychnine Alkaloid, Strychnine Sulfate, Nux Vomica,
Dog Button, Quaker Button

DOT - Poison B, poison label, 200 pounds

USCG - Poison B, poison label

IATA - Poison B, poison label, 25/kg passenger, 95 kg cargo

M.P. - 268°C

B.P. - 270°C

Sp. G. - 1.36

SOLUBILITY - 160 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Moderately persistent.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
1.7	.16	Lemon Shark	Incapacitated	Nitrate Salt	453

Mammals

Species	mg/kg B. W.	Administration Route	Ref.
Rat	16	Oral	453
Human	30-60	Oral - Lethal Dose	405
Mule Deer	20	Oral	165
Rat	5	Oral	8

Avian Toxicity

Pheasant	4-40	Oral	165
Small Game Birds	5-16	Oral	165
Golden Eagles	5	Oral	165
Sparrows	4-8	Oral	165

Amphibian Toxicity

Bullfrogs	2.2	Oral	165

STYRENE

Styrene is an important organic precursor employed in making plastics, resins, rubber, and insulators. The 4.4 billion lbs produced in 1971 (199) were shipped in containers ranging from small glass bottles to tank barges.

Styrene has a very limited solubility in water. When spilled it forms a colorless slick with only small amounts dissolving very slowly. The surface slick, exposed to air and light, will begin to oxidize and form peroxides and/or aldehydes with a penetrating odor. Elevated temperatures can lead to violent polymerization. The polymer is insoluble. The limited amount of dissolved styrene is subject to biodegradation. As much as 10 percent of the theoretical oxygen demand can be utilized in the first half day (5). The low solubility, however, should preclude development of any oxygen sags in a spill area.

Styrene is toxic to fish at low levels. The 96 hr TLm values for bluegill, fathead minnow, guppy, and goldfish range from 22 to 68 ppm (37). Concentrations as low as .25 ppm have been shown to affect the taste of flesh in native fish (4). Undissolved slicks pose a threat to waterfowl and marine mammals. In saltwater, the 48 hour TLm to brine shrimp is 52 ppm (425).

Styrene is considered more of an irritant than a toxic material. The oral LD_{50} for rats is reported as 4920 mg/kg body weight (174). Styrene vapors at 2000 ppm in air can be lethal to rats (8). Rats and rabbits exposed to 1300 ppm in air for 7-8 hr per day, 7 days a week for 26 weeks showed definite signs of eye and nasal irritation.

The odor threshold range for styrene solutions is .02-2.6 ppm (30).

NAME Styrene

PRODUCTION QUANTITY 4.4 billion lbs (1971)

SYNONYMS Styrol, Styrolene, Phenylethylene, Vinylbenzene, Cinnamol, Cinnamene

COMMON SHIP OR CONTAINER SIZE Glass bottles, 1-5 gal cans, 55 gal metal drums, tank trucks, tank cars, tank barges

M.P. -33 °C

B.P. 145 °C

Sp.G. 0.909

SOLUBILITY 320 mg/l at 25°C

PERSISTENCE

Oxygen Demand

BOD 412 - 18% Theo. with treatment plant activated sludge (5)
BOD_{36} - 11% Theo. measuring CO_2 evolution (26)
BOD_5, 10, 15, 20 - 65, 65, 78, 87% Theo. in freshwater - (425)
BOD_5, 10, 15, 20 - 8, 12, 21, 80% Theo. in saltwater - (425)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
51	96	Fathead Minnow	TLm		37
22	96	Bluegill	TLm		37
68	96	Goldfish	TLm		37
68	96	Guppy	TLm		37

Saltwater Toxicity

ppm	hrs	species	parm	cond	ref
68	24	Brine Shrimp	TLm		425
52	48	Brine Shrimp	TLm		425

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	4920	Oral	176

SULFURIC ACID

Sulfuric acid is a strongly corrosive, dense, oily liquid. It is colorless to dark brown depending on purity. The concentrated acid oxidizes, dehydrates, or sulfonates most organic compounds and is employed mostly by the fertilizer, chemical and petroleum industries. Users of large tonnages include titanium pigments, steel pickling, rayon, dyes and intermediates, and detergents. The 59 billion lbs produced in 1971 (199) in the United States were shipped by barge, rail and truck in glass bottles and carboys, metal barrels or drums with or without linings, tank trucks, tank cars, and tank barges. Containers may be glass, rubber or lead-lined.

Sulfuric acid is shipped in a concentrated form and though freely soluble in water will first sink when spilled, forming a submerged layer along the bottom. Field studies indicate this layer may persist for several days while acid dissolves up from the interface. Sulfuric acid dissociates in two stages. Below pH 1 some sulfate will remain as acid sulfate, HSO_4^-, but above that point all will be dissociated. Natural dilution and buffer capacity will neutralize spills slowly. Sulfuric acid may interfere with normal biological processes. A concentration of 50 ppm can inhibit sewage organisms 50 percent.

Sulfuric acid is generally directly lethal to fish in most natural waters only when the pH is reduced to 5.0 or lower (1). Concentrations above 6.25 mg/l have been found lethal to trout (1). A 96-hour median tolerance limit of 42 mg/l has been reported for mosquito fish in turbid water (1). A concentration of 29 mg/l was harmful for the waterflea, Daphnia magna, in soft water for 24-72 hours (1). The toxic threshold for the flatworm, Polycelis nigra, was found to be 0.63 mg/l in water of pH 3.2 (1). Bivalve larvae are affected at [illegible] mg/l (1). In salt water, a concentration of 42.5 mg/l for 48 hours killed half of the test prawn population in aerated water. Concentrations from 80-90 mg/l had the same results on shrimp and pogge(2), and 100 mg/l killed 10 percent of the oysters tested over a 120 hr period (1). Solution pH, buffer capacity and alkalinity will be important in determining resulting toxicity.

Sulfuric acid is highly hazardous by all means of contact. The oral LD50 for rats is reported to be 2140 mg/kg body weight (17). Drinking water should be limited to 250 ppm sulfates to avoid intestinal disturbances (7). Similarly, water for livestock should not exceed 500 ppm sulfates(41).

NAME Sulfuric Acid

PRODUCTION QUANTITY 59 billion lbs-1971

SYNONYMS Oil of Vitriol, Oleum

COMMON SHIP OR CONTAINER SIZE Bottles, carboys, barrels, drums,
tank trucks, tank cars, tank barges

DOT Corrosive Liquid, White Label, 10 pts in outside container

M.P. 10.35 °C

B.P. 340 °C Decomposes

Sp.G. 1.834

SOLUBILITY Freely

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
1000	.5-.75	Goldfish	Lethal	Hard	144
169	.86-1.16	Goldfish	Lethal	Hard	144
143	2.5-5.3	Goldfish	Lethal	Soft	144
143	3.0-2.35	Goldfish	Lethal	Hard	144
138	5-6	Goldfish	Lethal	Soft	144
138	4-8	Goldfish	Lethal	Hard	144
134	6.2-96	Goldfish	Lethal	Soft	144
59	1.0-1.25	Goldfish	Lethal	Very Soft	144
50	1-3	Daphnia Magna	Lethal	Soft	144
38	24	Daphnia Magna	Lethal	Soft	144
30	24	Daphnia Magna	Lethal	Soft	144
29	24-72	Daphnia Magna	Lethal	Soft	144
20	168	Daphnia Magna	Lethal	Soft	144
10	168	Daphnia Magna	Lethal	Soft	144
1	168	Daphnia Magna	Lethal	Soft	144
0.1	168	Daphnia Magna	Lethal	Soft	144
50	1-3	Daphnia Magna	Lethal	Static-Soft	109
38	24	Daphnia Magna	Lethal	Static-Soft	109
30	24	Daphnia Magna	Lethal	Static-Soft	109
23	24-72	Daphnia Magna	Lethal	Static-Soft	109
20	168	Daphnia Magna	Lethal	Static-Soft	109
10	168	Daphnia Magna	Lethal	Static-Soft	109
1	168	Daphnia Magna	Lethal	Static-Soft	109
0.1	168	Daphnia Magna	Lethal	Static-Soft	109

ppm	hrs	species	harm	cond	ref
1000	1/2-3/4	Goldfish	Lethal		109
143	2.5-5	Goldfish	Lethal		109
138	5-6	Goldfish	Lethal		109
134	6-96	Goldfish	Lethal		109
.63		Polycelis Nigra	Toxic Threshold	pH 3.2	1
29	24-72	Daphnia Magna	Harmful	Soft, pH 5	1
33.11		Bivalve Larvae	Harmful		1
50		All Aquatic Life	Harmful		1
88	64	Daphnia Magna	Harmful	Lake Erie	1
138		Daphnia Magna	Harmful		1
1.2		Sunfish	Lethal		1
6.0-8.0	6	Minnows	Lethal	Distilled, 20°C	1
6.25	24	Trout	Lethal		1
7.36	60	Bluegills	Lethal	Distilled	1
10.0		Gamefish	Lethal		1
24.5	24	Bluegills	Lethal		1
26.0	.25	Minnows	Lethal	Tap	1
42	96	Mosquito Fish	TLm	Turbid	1
49	48	Bluegill, Sunfish	TLm	Tap, 20°C	1
59.0	1-1.25	Goldfish	Lethal	Soft, pH3.2	1
71.2		Pickerel	Lethal		1
80.1		Whitefish	Lethal		1
110-120	6	Minnows	Lethal	Hard, 20°C	1
138.0	4	Goldfish	Lethal	Hard, pH 4	1
167	48	Fish	Lethal		1

Salt Water Toxicity

100	120	Oysters	10% Lethal		1
42.5	48	Prawn	LC50	Aerated	2
80-96	48	Shrimp	LC50	Aerated	2
200-500	48	Cockle	LC50	Aerated	2
80-90	48	Pogge	LC50	Aerated	2
100-330	48	Flounder	LC50	Aerated	2
90	48	Crab	LC50	Aerated	2

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	3140	Oral	17

SULFUR MONOCHLORIDE

Sulfur chloride is employed to produce synthetic rubber, dyes, pesticides, and various organic chemicals. The 8,800 tons produced in 1951 (198) were shipped in metal drums, tank cars, and tank trucks.

Sulfur chloride decomposes upon contact with water forming hydrogen sulfide, sulfur, sulfites, thiosulfuric acid, and hydrogen chloride. These materials have varying half-lives in natural waters and are capable of undergoing additional transformation.

The hazard posed by sulfur chloride to aquatic life will be that of its hydrolysis products. Sulfur chloride itself is a strong irritant with vapors which can kill mice in one minute when present at 150 ppm or greater (38).

NAME Sulfur Chloride

PRODUCTION QUANTITY 8,000 tons (1951) (198)

SYNONYMS Sulfur Subchloride, Disulfur Dichloride, Sulfur Monochloride

COMMON SHIP OR CONTAINER SIZE Metal drums, tank cars, tank trucks

DOT Corrosive Liquid, White Label, 1 gallon outside container

USCG Corrosive Liquid, white label

M.P. -77. °C

B.P. 138. °C

Sp.G. 1.67

SOLUBILITY Decomposes

PERSISTENCE

Chemical Hydrolysis, etc.

Decomposes in water to hydrogen sulfide, sulfur, sulfite, thiosulfuric acid, and hydrochloric acid.

TOXICOLOGICAL

Fresh Water Toxicity

See the various hydrolysis products. HCL will control toxicity.

Salt Water Toxicity

See the various hydrolysis products. HCL will control toxicity.

2,4,5-T AND SILVEX

Silvex and 2,4,5-T are phenoxycarboxylic acid herbicides used to control broadleaf plants. The six million lbs of 2,4,5-T and three million lbs of silvex produced in 1971 (127) were applied as emulsion concentrates.

The phenoxy acid herbicides are relatively insoluble, but can disperse through water when spilled as an emulsion concentrate. In moist soil, .5-3 lb/acre silvex persisted 2-5 weeks at temperature climate. When applied at 25 ppm to soil, persistence surpassed 103 days. A concentration of 5 ppm 2,4,5-T to soil persisted for more than 190 days. In moist soil, 2,4,5-T generally persists for three months (22).

The phenoxy carboxylic acid herbicides are generally toxic to aquatic life. The 96 hr TLm for bluegill is 24 ppm while corresponding 48 hr values for chinook salmon, and rainbow trout are 1.27 ppm (330) and 1.4 ppm (354). Fathead minnows exhibit a 96 hr median threshold limit of 7.2 ppm (39). Work with 2,4,5-T indicates somewhat higher limits of 55 ppm for perch (1). Fish food organisms are affected in the same range (354). Daphnia pulex are immobilized when exposed to 2.9 ppm (335). In salt water, oysters display 20 percent reduced growth and phytoplankton 70 percent inhibition when placed in 1 ppm. The EC50 values for brown shrimp and spot are .24 ppm and .36 ppm (23). Silvex at 1-5 ppm can kill fertilized fish eggs (6).

The 2,4,5-T formulation is somewhat more toxic than Silvex. Oral LD50 values for the first average 300 mg/Kg body weight in rats while for the second they are 650 mg/Kg (1). It is estimated that 56 gms of 2,4,5-T is the lethal dose for a 70 Kg man (1).

In birds, 2500-5000 ppm is sufficient to suppress reproduction almost 100 percent. LD50 values fall in the range 2000-5000 for upland game birds. Similar levels are reported for 2,4,5-T (22).

As herbicides, the phenoxy carboxylic acids can affect plant growth at low levels. Silvex at 1 ppm for four hours can reduce phytoplankton productivity 70 percent. The same level of 2,4,5-T had no such effects (22).

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NAME 2,4,5-T and Silvex

PRODUCTION QUANTITY 63 million lbs - 1971 (327)

SYNONYMS 2-(2,4,5-Trichlorophenoxy)-Propionic Acid; Silvex; Fenoprop; 2-4-5-TCPPA; 2-4-5-TP

M.P. Silvex 181.6 °C 2,4,5-T 174 °C

Sp.G. Silvex 1.209 2,4,5-T 1.662

SOLUBILITY Silvex and 2,4,5-T 140 ppm at 25 °C

TOXICOLOGICAL

PPM	HRS	SPECIES	[illegible]	COND	REF
Silvex					
7	72	Shiners	50% Kill		1
1.23	48	Chinook	TLm		1
1.5	24	Bass	TLm		1
1.35	24	Chinook	TLm		330
25 lb/acre		Spatterdock	5-10% Control		350
0.32	96	Pteronarcys Sp (Nymphs)	TLm	Temp 60°F	103
2.9	24	Bluegill	TLm		388
2.4	48	Bluegill	TLm		388
2.4	64	Simocephalus Serrulatus	Immobile	Temp 70°F	335
3.0	64	D. Pulex	Immobile	Temp 70°F	335
.2-3		Aquatic Weeds	75-100% Lethal	Ponds	389
83	48	Bluegill	TLm	K Salt Liquid	390
2.4	96	Bluegill	TLm		391
7.2	96	Fathead	TLm		391
1.4	48	Rainbow	EC50		354
16.6	48	Bluegill	EC50		354
0.76	48	Pteronarcys Cal.	EC50		354
2.4	48	Simocephalus Serrulatus	EC50		354
3.0	48	D. Pulex	EC50		354
.00034	96	Pteronarcys Cal. (Naiads)	LC50	Temp 15.5°C	104
2,4,5-T					
55		Perch	Threshold Limit	2,4,5-T	1
60		Bleak	Threshold Limit	2,4,5-T	1
1.6	24	Salmon	TLm	Esters	329
2	72	Microcysts Aeruginosa	Lethal		33

ppm	hrs	species	parm	cond	ref
21.8 lb/acre		Spatterdock	30 Control	Lakes	350
100	48	Bluegill	TLm	Dimethyl Amine	352
1.4	48	Bluegill	TLm	Butoxyethanol Ester	352
26	48	Bluegill	TLm	Isooctyl Ester	352
17	48	Bluegill	TLm	Propylene Glycol Butyl Ether Ester	353
2.9	24	Bluegill	TLm	Oleic 1,3-Propylene Diamine	357
1.8	24	Bluegill	TLm	Isopropyl Ester	357
53.7	24	Bluegill	TLm	Triethyl Amine	357
11.0	24	Bluegill	TLm	Acid	403
75	72	Shiners	100% Kill	50°F, Huron	426
50	72	Shiners	No Toxic Effect	50°F, Huron	426

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
Silvex					
0.32	48	Spot	50% Kill		347
0.41	24	Sheepshead Minnow	EC50		330
0.36	48	Sheepshead Minnow	EC50		330
1	96	Oyster	20% Growth Decline		23
.24	48	Brown Shrimp	EC50		23
.36	48	Spot	EC50		23
2,4,5-T					
1	4	Phytoplankton	70% Inhibition		23
.32	48	Spot	50% Kill		347
.14	96	Oyster	EC50	Polyglycol Butyl Ether Ester	23
1	24	Brown Shrimp	No Effect	Acid	23
1	48	Brown Shrimp	20% Lethal	Polyglycol Butyl Ether Ester	23
1	4	Phytoplankton	89% Inhibited	Polyglycol Butyl Ether Ester	23

Mammalian

species	mg/kg B.W.	administration route	ref
Silvex			
Rat	650	Oral	1
Rabbit	>1000	Oral	161
2,4,5-T			
Rat	300	Oral	1
Dog	100	Oral	140

TDE

TDE, or DDD, was formerly an insecticide used on fruits and vegetables. It is no longer in production.

The colorless crystals are insoluble in water and once released, act very similar to DDT. The chemical is persistent and will be associated with bottom sediments.

TDE is relatively toxic to aquatic life. The 96 hour TLm to bluegill is 0.01 ppm.[111] The 48 hour LC_{50} for rainbow trout is 0.009 ppm.[11] The fish food organisms Simocephalus serrulatus and Daphnia pulex are immobilized by 0.0045 and 0.0032 ppm respectively.[111] In saltwater, the 48 hour TLm to brown and white shrimp is 0.15 ppm and 0.075 ppm.[111]

TDE has been preferred to DDT when in use because of its lower toxicity to mammals. The oral LD_{50} for rats is 3400 mg/kg body weight.[1] While toxicity to birds occurs at the same levels, TDE poses a special threat to them through its ability to empare embryo survival and reproduction success. Concentrations of 10-40 ppm reduced productivity in mallards 50 percent.[11] Tests have also revealed TDE to be potentially carcinogenic, but teratogenic response was negative.[11]

DDD has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill events are probabilistic, median receptors have been selected for use of determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

TDE

SYNONYMS - 2,2-Bis(p-chlorophenyl)-1,1-dichloroethane, DDD, Rothane, Tetrachlorodiphenylethane

COMMON SHIP OR CONTAINER SIZE - Fiber drums

M.P. 110°C

B.P. 193°C

Sp. G. - 1.29

SOLUBILITY - Practically insoluble

PERSISTENCE

Oxygen Demand - Similar to DDT and, therefore, considered persistent.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
<2.6	96	Catfish	Tlm		1
1.0		Goldfish	Tlm		1
0.03	96	Bluegill	Tlm		129
10	24	Rainbow Trout	Tlm	55°F	175
0.1 lb/acre	168	Chironomid Larvae	50% Kill	Lab	421
0.5 lb/acre	168	A. Aquaticus	50% Kill	Lab	421
2 lb/acre	168	Tubificid Worms	10% Kill	Lab	421
0.46	36	Mosquito Fish	Lethal		176
0.0045	48	Simocephalus Serrulatus	Immobilized	60°F	135
0.0032	48	Daphnia Pulex	Immobilized	60°F	135
0.38	96	P. Californica (Naiads)	LC_{50}	15.5°C	184
0.056	24	Bluegill	LC_{50}		22
0.009	48	Rainbow Trout	LC_{50}		22
0.0056	24	Gammarus Lacustris	LC_{50}		22
1	24	P. Californica	LC_{50}		22
0.0018	48	Gammarus Lacustris	LC_{50}		22
0.0032	48	Daphnia Pulex	LC_{50}		22
1.1	48	P. Californica	LC_{50}		22
0.042	96	Bluegill	LC_{50}		101

Saltwater Toxicity

ppm	hrs	Species	Para	Cond.	Ref.
0.15-0.2	48	Brown Shrimp	TLm		110
0.075-0.090	48	White Shrimp	TLm		110
0.0068	24	Brown Shrimp	EC_{50}	28°C	21

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	3400	Oral	1
Mouse	2280	Oral	22

Avian Toxicity

Mallards	4800-5100 ppm	LC_{50}-5 days	22
Pheasants	560-600 ppm	LC_{50}-5 days	22
Bobwhites	2200-2400 ppm	LC_{50}-5 days	22
Coturnix	130-1500 ppm	LC_{50}-5 days	22

TETRAETHYL LEAD

Tetraethyl lead is a colorless, oily liquid with a pleasant characteristic odor. The 370 million lbs produced in 1969 (189) in the United States were used as a gasoline additive to prevent knocking in internal combustion engines and for certain ethylation operations. It is shipped by barge, rail, and truck in 55 gallon tight metal containers.

Tetraethyl lead is practically insoluble in water. When spilled, it will seek the bottom and form a submerged layer. Dissolution will proceed very slowly. Exposure to sunlight will degrade the tetraethyl lead to toxic triethyl lead. Little biological action is predicted; rather the subsurface blanket will persist in low spots and eddies, providing a continuing source of lead to the water.

Tetraethyl lead is toxic to fish at low concentrations. The 24, 48, and 96 hr Tlm values for Bluegill have been reported as 2.0 ppm, 1.4 ppm (1), and 0.2 ppm (15), respectively. The latter concentration is estimated as generally safe. Lead is bioconcentrative in fish and mammals. Organic lead is especially hazardous in this sense because of its affinity for lipid fluids.

Tetraethyl lead is toxic by all routes of exposure. The intraperitoneal LD50 for rats has been reported as 10 mg/kg body weight (1). Drinking water should not contain more than .05 ppm lead (7). Similarly, water for livestock should not exceed .2 ppm lead (7). Tetraethyl lead can be absorbed through skin at toxic levels(18).

NAME Tetraethyl Lead

PRODUCTION QUANTITY 170 million lbs-1969

SYNONYMS Lead Tetraethyl, TEL

COMMON SHIP OR CONTAINER SIZE 55 gal drums

DOT Class B Poison, Poison Label, 55 gal in outside container

USCG Poison B, Poison Label

M.P. 125 °C Decomposes

B.P. 198 °C Decomposes

Sp.G. 1.659

SOLUBILITY 80 mg/l at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
2	24	Bluegill	TLm	Philadelphia Tap	1
1.4	48	Bluegill	TLm	Philadelphia Tap	1
.2	96	Bluegill	TLm		15

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	10	Intraperitoneal	1

Tetraethyl Pyrophosphate

Tetraethyl pyrophosphate, or TEPP, is a contact poison that has been found to be highly effective against mites and soft bodied insects. The less than 1 million lbs produced in 1971 were used on many food crops because of the materials low residence time.

TEPP is a mobile, hygroscopic liquid miscible with water. It is also readily hydrolysed by moisture or water and, therefore, is not persistent. The half life in water at 25°C (50 v/v mixture) is reported as 7 hours.[8]

TEPP is quite toxic to aquatic life. The 96 hour LC_{50} values for fathead minnow and bluegill are 1.7 and 0.84 ppm respectively.[112] Water quality does not appear to have a significant affect on toxicity.[112] Some forms of algae are destroyed by a concentration of 500 ppm while the amphipod Gammarus lacustris has 48 hour LC_{50} for oyster eggs and larvae are greater than 10 ppm.[111]

TEPP is a very toxic contact poison requiring special handling precautions. It can be lethal through oral, dermal, or inhalation contact. The oral LD_{50} for rats is 1.2-2 mg/kg body weight.[11] Birds and amphibians are affected at similar levels.[11] Small doses at frequent intervals can be additive, but chronic poisoning does not result from irreversible damage since the action is on the cholinesterase enzyme which can be continually produced by the body. A TLV of 0.5 mg/m^3 has been recommended.[11]

TETRAETHYL PYROPHOSPHATE

SYNONYMS - TEPP, Bladan, Nifos T, Vapotone, Tetron, Killax, Mortopal, Kilmite, Ethyl pyrophosphate, TEP

PRODUCTION QUANTITY - <1,000,000 lbs 1971

COMMON SHIP OR CONTAINER SIZE - 5 gal. cans, 30 and 55 gal. drums

DOT - Class B Poison, Poison label, 1 quart in an outside container

IATA - Poison B, Poison label, not acceptable passenger, 220 liters cargo

M.P. 170-213°C decomposes

B.P. 138°C at 2.3 mm

Sp. G. - 1.185

SOLUBILITY - Miscible

PERSISTENCE

Chemical Hydrolysis, etc. - Rapidly hydrolyzes in water -- half life at 25°C about 7 hours in a 50 v/v mixture.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm.	Cond.	Ref.
0.39	48	Fathead Minnow	LC_{50}		22
0.052	48	Gammarus Lacustris	LC_{50}		22
0.074	24	Gammarus Lacustris	LC_{50}		22
1.7	96	Fathead Minnow	LC_{50}		402
0.84	96	Bluegill	LC_{50}		402
1.0	96	Fathead Minnow	LC_{50}		402
2.3	24	Channel Catfish	lethal	Tap	402
500		Protococcus sp, Chlorella sp	No Growth		402
500		Phaeodactylum tricornutum, Dunaliella sp, Monochrysis lutheri	Killed		402
2.1	96	Fathead Minnow	TLm	Soft- acetone or alcohol	402
1.3	96	Bluegill	TLm	Soft- acetone or alcohol	402
21	96	Goldfish	TLm	Soft- acetone or alcohol	402

1.8	96	Guppy	TLm	Soft- acetone or alcohol	402

Saltwater Toxicity

>10	48	Oyster Eggs	LC_{50}	411
>10	48	Oyster Larvae	LC_{50}	411

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1.2-2.0	Oral	22
Rabbit	5	Topical	8
Mouse	1.7	Intraperitoneal	96

Avian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Young Mallards	3.6	Oral	22
Young Pheasants	4.2	Oral	22
Young Chucker Partridges	10.1	Oral	22

Amphibian Toxicity

Bullfrogs	89.1	Oral	22

TOLUENE

Toluene is used in the manufacture of dyes, explosives, benzaldehyde, benzoic acid and other organic compounds. It is also used as a solvent and extractive. The 6 billion lbs produced in 1971 (199) was shipped in a wide variety of containers. Of importance from a spill hazard viewpoint is the wide use of tank trucks, tank rail cars and tank barges.

Toluene is soluble in water to a very limited extent. When spilled, it will form a colorless slick and dissolve very slowly. Toluene can be oxidized in air to form phenol, but the reaction generally requires catalysis. Dissolved toluene is biodegradable with acclimation. While sewage seed consumed no oxygen during 5 days incubation (11), acclimated seed may require up to 1.23 lb/per lb of toluene(4). Excess toluene may interfere with biological action. Concentrations greater than .05 percent inhibit sewage sludge. This inhibition and toluene's low solubility should preclude development of oxygen deficiencies in a spill situation.

Toluene can be toxic to fish and fish food organisms. The 96 hr Tlm for fathead minnows, bluegill, goldfish, and guppy have been reported as 44 ppm, 24 ppm, 63 ppm, and 66 ppm, respectively (37). A similar value for mosquito-fish has been reported as 1180 ppm (1). The toxic threshold for Daphnia is 60 ppm (1). In salt water, 10 ppm has been found to reduce the photosynthetic activity of giant kelp (1). Less than .25 ppm is sufficient to taint the flavor of fish flesh. In saltwater, the 24 hour Tlm to brine shrimp is 23 ppm (425).

Toluene is moderately toxic when ingested or inhaled(38). The average oral LD50 for mammals is greater than 5000 mg/Kg body weight (15). It is suggested that human consumption not exceed 1.7 mg/Kg (63). Chronic feeding of .25, 1.0, and 10 mg/Kg for 19 1/2 and 5 mo. periods had no effect on rabbits (15). Toluene is a slight hazard with absorption through skin. Water likely to be used for prolonged human contact should not exceed 600 ppm (7).

Tests for carcinogenesis have been negative (15).

NAME Toluene

PRODUCTION QUANTITY 6 billion lbs-1971

SYNONYMS Phenylmethane, Toluol, Methyl Benzene

COMMON SHIP OR CONTAINER SIZE Bottles, cans, drums, tank cars, tank trucks, tank barges

DOT Flammable Liquid, Red Label, 10 gal.

USCG Grade C flammable liquid

M.P. -95 °C

B.P. 110.6 °C

Sp.G. 0.866

SOLUBILITY 470 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

$BOD_{.125}$ = 2% Theo. using a phenol acclimated pure bacterial culture (5)
$BOD_{.5}$ = 47% Theo. using phenol acclimated activated sludge (13)
BOD_5 = 0 lb/lb with sewage seed (11)
BOD_5 = 1.23 lb/lb when acclimated (4)
BOD_8 = 34.0% Theo. with aniline acclimated treatment plant activated sludge (5)
COD = 1.88 lb/lb (4)
BOD_5, 10, 15, 20 = 53, 62, 70, 80% Theo. in freshwater - (425)
BOD_5, 10, 15, 20 = 73, 74, 80, 86% Theo with acclimation - (425)
BOD_5, 10, 15, 20 = 3, 2, 3, 63% Theo. in saltwater - (425)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
61	1	Sunfish	Lethal		15
1118	96	Sunfish	Tlm		15
1340	24	Mosquito Fish	Tlm	20°C	1
1260	48	Mosquito Fish	Tlm	20°C	1
1180	96	Mosquito Fish	Tlm	20°C	1
60		Daphnia	Threshold		1
34	96	Fathead Minnow	Tlm		17
24	96	Bluegill	Tlm		17
58	96	Goldfish	Tlm		17
59	96	Guppy	Tlm		17
22-65	1	Sunfish	Lethal		109

ppm	hrs	species	parm	cond	ref
10		Giant Kelp	Reduced Photosynthesis		1
Saltwater Toxicity					
33	24	Brine Shrimp	TLm		425

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	5000	Subcutaneous	1
White Rat	7000	Oral	1
Young Rat	2580	Oral	63
Rat	5850	Oral	63
Rat	800	Intraperitoneal-Lethal	113
Mammals	>5000	Oral	15

TOXAPHENE

Toxaphene is one of the polychlorinated aromatic insecticides used on cotton, grains, vegetables, forage crops, soybeans, and livestock. The 50 million lbs produced in 1971 (327) were applied in the dust, granule, wettable powder, and emulsion concentrate forms.

Toxaphene is insoluble in water, but will disperse if spilled in a wettable form. Pure toxaphene dehydrohalogenates in strong sunlight. Micro-organisms are also capable of detoxifying the insecticide upon standing. Even at that, however, some lakes treated with toxaphene have remained toxic for 3-4 years (6). When applied to soil at 140 ppm, residues survived for more than six years. Applications of 50 ppm to soil were reduced 50 percent over an 11 year period and after 14 years, 40 percent survived in sandy loam soil originally treated with 100 ppm (22).

Toxaphene is extremely toxic to most aquatic life. The 96 hr TLm values for fathead minnows, trout, chinook salmon, and stickleback are .013 ppm (1), .0135 ppm (329), .0025 ppm and .0078 ppm (342) respectively. Goldfish are killed by .005 ppm (1) and total fish kill in lakes has resulted from .015-.036 ppm (392). Fish food organisms are similarly affected (335,354). Daphnia pulex are immobilized at .015 ppm (335). In salt water, shrimp exhibit a 48 hr TLm of .04-.09 ppm (330). Spot are killed in 24 hrs by .0032 ppm (395) and mullet sustain .50 percent mortality (347).

Aquatic life concentrates toxaphene readily. Daphnia and periphyton accumulated chronic doses of .01-.02 ppm to levels toxic to fish. Oysters exposed to 0.05 ppm for 10 days concentrated toxaphene by a factor of 2020. Aquatic plants may also accumulate the toxicant (22).

Toxaphene is highly toxic when ingested. The oral LD50 for rats has been reported as [illegible] 90 mg/Kg body weight (1), while that for dogs was 25 mg/Kg (340). The estimated acute oral dose in man is 2-7 grms (1). Drinking water should not contain more than .001 ppm toxaphene (337). In chronic feeding studies, doses as low as 4 mg/Kg/day caused abnormal reactions in dogs (1).

Birds are also quite sensitive to toxaphene. The reported LD50 values for young mallard ducks, young pheasants, and sharp tailed grouse are 70.7 mg/Kg, 40 mg/Kg, and 10-20 mg/Kg respectively. LC50 values fall in the range 500-650 ppm. Low level diets of 25-50 ppm reduce reproduction. Pelicans have displayed a much lower tolerance to toxaphene than DDT. In the wild, fish eating birds suffer greatly from accumulation of toxaphene in their diet (22).

Toxaphene has some phytotoxic properties. Exposure of phytoplankton for four hrs to 1 ppm reduced productivity 91 percent (22). Toxaphene in irrigation water is thought to depress growth in seedlings (1).

Toxaphene has been designated a toxic substance under Section 307 of the Federal Water Pollution Control Act Amendments of 1972. As such, continuous discharge standards are being established for various sources. These levels relate to continual exposure and therefore should not be compared directly with critical concentrations established here. Indeed, since spill event are probabilistic, median receptors have been selected for use in determining critical concentrations in setting harmful quantities and rates of penalty as opposed to the most sensitive receptor.

NAME Toxaphene

PRODUCTION QUANTITY 50 million lbs - 1971 (327)

SYNONYMS Chlorinated Camphene with 67-69% Chlorine; Chlorinated-Camphene; Compound-3956; Alltox; Geniphene; Toxakil, Toxadust; Phenacide Fenphene

M.P. 90 °C

Sp.G. 1.66

SOLUBILITY 1.50 ppm at 25 °C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
.005	240	Goldfish	TLm		1
.05		Bass	100% Kill		1
.013	96	Fathead	TLm		1
0.1	72	Carp	100% Kill		1
.003	30	Goldfish	100% Kill		1
.02		Bluegill	100% Kill		1
.05	20	Goldfish	100% Kill		1
.0135	96	Trout	TLm		329
.0165	96	Trout	TLm		329
.0051	96	Fathead	TLm		330
2.5	24	Fingerling Channel Catfish	Lethal	Tap	323
.015-.036		Total Fish Kill	Kill	Lakes	392
.0094	96	Coho	TLm		342
.0025	96	Chinook	TLm		342
.0084	96	Rainbow	TLm		342
.0078	96	Threespine Stickleback	TLm		342
.0135-.0165	96	Rainbow	TLm	Lakes	376
.5	1.5	Gammarus Lacustris Lacustris	50% Kill		343
.04-.15		Algae	No Growth or Kill		95
.5 lb/acre	24	Mosquito Fish	100% Kill	Ponds	344
.5 lb/acre	24	Catesbeiana Tadpoles	100% Kill	Ponds	344
.005-.0059		Mosquito Fish	LC50		393
5.4	96	Rainbow	TLm	Temp 55°F	303
2.7	96	Rainbow	TLm	Temp 65°F	303
1.8	96	Rainbow	TLm	Temp 75°F	303
.019	48	Simocephalus Serrulatus	Immobile	Temp 60°F	335

ppm	hrs	species	parm	cond	ref
.015	48	D. Pulex	Immobile	Temp 60°F	135
.007	48	Pteronarcys Cal.	EC50		154
.047	48	Baetis Sp	EC50		154
.035		Resident Fish	MLD	N. Dak. Lakes	194
.0075	96	Fathead	TLm		110
.0035	96	Bluegill	TLm		110
.0056	96	Goldfish	TLm		110
.020	96	Guppies	TLm		110
.0076	24	Rainbow	LC50		110
.0072	24	Bluegill	LC50		110
.005		Rainbow & Brown	LC50		111
.0056	96	Goldfish	LC50		111
.010		Bluegill	LC50		111
.05	24	Rainbow	LC50		111
.013	96	Catfish	TL50	Predicted	160
.005	96	Bullhead	TL50	Predicted	160
.014	96	Goldfish	TL50	Predicted	160
.014	96	Minnow	TL50	Predicted	160
.004	96	Carp	TL50	Predicted	160
.013	96	Sunfish	TL50	Predicted	160
.018	96	Bluegill	TL50	Predicted	160
.002	96	Bass	TL50	Predicted	160
.011	96	Rainbow	TL50	Predicted	160
.003	96	Brown	TL50	Predicted	160
.008	96	Coho	TL50	Predicted	160
.012	96	Perch	TL50	Predicted	160

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
.0032	48	Mullet	50% Kill		147
.04-.05	48	Brown Shrimp	TLm		110
.075-.09	48	White Shrimp	TLm		110
.0032	24	Spot	100% Kill		195
.1	4	Larval Lampreys	Began to Die	Mich. Bay	196
.1	3-4	Small Fish	Peak Mortality	Mich. Bay	196
.08	360-480	Petromyzon Marinus (Larvae)	Killed	Mich. Bay	196
.0054	24	Spot	Lethal		197
.0018	48	Spot	Lethal		197

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	69	Oral	1
Rat	90	Oral	1
Dog	25	Oral	140
Mule Deer	190	Oral	115

Trichlorfon

Trichlorfon, or Dylox, is an organophosphate insecticide. It is registered for use on a wide variety of field crops, seed crops, vegetables, and ornamentals to control many different species of insects. In alternate forms it is also used as a bait and livestock parasite control.

Trichlorfon is a crystaline substance soluble in water to 130,000 ppm. Like many organophosphates, it is subject to decomposition under alkaline conditions. It is relatively persistent, however, and has been found at detectable levels up to 256 days after application in water at 20°C.[22]

Trichlorfon is toxic to aquatic life. The 96 hour Tlm to bluegill in soft waters is 3.8 ppm.[423] Hardness appears to increase toxicity. The 96 hour Tlm values for fathead minnows in soft and hard water are reported to be 180 ppm and 0.051 ppm respectively.[338] The 96 hour LC_{50} value for striped bass fingerlings is 5.2 ppm.[418] Anthropods such as Daphnia carinata, Simocephalus serrulatus, Daphnia magna, and Daphnia pulex are immobilized in the range 0.00012-0.0007 ppm.[338] In salt water, the 336 hour LC_{50} to oyster larvae is 1.0 ppm.[411] Marine plankton is destroyed in the range 100-1000 ppm.[95]

Trichlorfon is a cholinesterase enzyme inhibitor, but is not as toxic as materials such as TEPP. The oral LD_{50} for rats is 450 mg/kg body weight.[22]

TRICHLORFON

SYNONYMS - Dipterex, Dylox, Dyrex, Neguvon, Anthon, Bayer L 13/59, Tugon, Chlorofos, Dipterex, O,O-Dimethyl-2,2,2-trichloro-1-hydroxyethylphosphonate, Bovinox, Equino-Aid, Trinex, Trichlorphon

M.P. 84°C

B.P. 100°C

Sp. G. - 1.73

SOLUBILITY - 130,000 ppm @ 20°C

PERSISTENCE

Oxygen Demand - Relatively persistent.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
50	60	Goldfish	100% Kill		1
51	96	Minnow	TLm		1
180	96	Fathead Minnow	TLm	Soft	330
0.051	96	Fathead Minnow	TLm	Hard	330
0.02	180	Trout	Toxic Effects	Stream	422
0.6	24	Chaoborus Astictopus	Fourth Instar Larvae		179
3.8	96	Bluegill	TLm	Soft	2/23
0.00012	64	Daphnia Magna	Immobilization	70°F	135
0.00025	64	D. Carinata	Immobilization	70°F	135
0.0007	64	Simocephalus Serrulatus	Immobilization	70°F	135
0.00018	64	Daphnia Pulex	Immobilization	70°F	135
10.4	24	Striped Bass	LC_{50}		22
[illegible]	48	Rainbow Trout	LC_{50}		22
0.05	24	Pteronarcella Badia	LC_{50}		22
0.092	24	Gammarus Lacustris	LC_{50}		22
0.11	24	Claassenia Sabulosa	LC_{50}		22
0.32	24	P. Californica	LC_{50}		22
0.00018	48	Daphnia Pulex	LC_{50}		22
0.0081	48	Daphnia Magna	LC_{50}		22
0.022	48	P. Badia	LC_{50}		22
0.06	48	Gammarus Lacustris	LC_{50}		22

0.18	48	P. Californica	LC_{50}	22
5.2	96	Striped Bass Fingerlings	LC_{50}	410

Saltwater Toxicity

1.0	136	Oyster Larvae	LC_{50}	411
100-1000		Marine Plankton	Lethal	95

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	450	Oral	22
Rat	750	Oral	1

Avian Toxicity

Bobwhite	700-800 ppm	LC_{50}-5 days	22
Coturnix	1800-2000 ppm	LC_{50}-5 days	22

TRICHLOROPHENOL

Trichlorophenol is used primarily as a bactericide. Production reached 20 million lbs in 1969 (199) and appears to be growing steadily.

Trichlorophenol is soluble to a small extent in water. When spilled, it will sink and dissolve very slowly. Tests for biodegradability indicate use of 4.1 percent of the theoretical oxygen demand in .94 days (5). Within three days, however, acclimated cultures may effect release of 75 percent of the chlorine (87). The poor degradation results from bactericidal properties. Concentrations greater than 50 ppm can inhibit biological systems (64). The Tlm for sewage bacteria is reported as 60 ppm.

Trichlorophenol is quite toxic to fish. The 96 hr Tlm for fathead minnows is reported to be .1-1 ppm under static conditions while 1.75 is lethal in 3 hrs under flow through conditions.(64) Bluegill and trout exposed to 5 ppm die in 2 hrs (5). An average 24 hrs Tlm of 3.4 ppm has been reported for fish (87). Diatoms are inhibited by 4 ppm while the same concentration may be 88-97 percent fatal to stalked ciliates over a 2-4 wk period(64). The undissolved layer of trichlorophenol also threatnes all benthic life forms. Trichlorophenol is toxic to the algae Chlorella pyrenoidosa at 1.5 ppm (4). Waterfowl may be damaged by concentrations of phenols in excess of 25 ppm(41).

Trichlorophenol is highly toxic by all routes of exposure. The oral LD50 for rats has been reported as 2960 and 820 mg/Kg body weight for the 2,4,5 and 2,4,6 isomers, respectively (8). Drinking water should not contain more than .001 ppm phenols (49), but this is predicated largely on organoleptic properties. Trichlorophenol has an odor threshold in water near 0.1 ppm (1). Chronic feeding of 300 and 500 mg/Kg body weight to rats has had no effect (1). Water for livestock, however, should be kept free of concentrations in excess of 1 ppm phenols (42). Phenols can be absorbed through the skin at toxic levels. Water for body contact should be limited to 10 ppm phenols if fresh (40) and 1 ppm if saline (41).

NAME Trichlorophenol

PRODUCTION QUANTITY 28 million lbs-1969

M.P. 67 °C

B.P. 252 °C

Sp.G. 1.49

SOLUBILITY 800 mg/l at 25 °C

PERSISTENCE

Oxygen Demand

BOD,84 = 4.1% Theo. with a pure bacterial culture-(5)
BOD_5 = 0.4 mg/l oxygen demand-(156)
BOD_5 = 75% chlorine release with acclimated culture-(97)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	param	cond	ref
5	2	Bluegill	Lethal		5
6	2	Trout	Lethal		5
1.8	24	Fish	Tlm		97
.1-1	96	Fathead Minnow	Tlm	Static	64
1.75	1	Fathead Minnow		Flow Through	64
4	3-4 wks	Stalked Ciliates	80-92% Kill	Flow Through	64
4	3-4 wks	Diatoms	Inhibits	Flow Through	64

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	2960	Oral-2,4,5 isomer	8
Rat	820	Oral-2,4,6 isomer	8

TRIETHYLAMINE

Triethylamine is used as a catalytic solvent in chemical synthesis; in the manufacture of accelerator activators for rubber, and wetting, penetrating and waterproofing agents of quaternary ammonium types; as a solvent; as a corrosion inhibitor, and as a propellant. The 5.6 million lbs sold in 1969 (199) were shipped in 1-gallon and 5-gallon cans, 55-gallon drums, and in tank cars.

Triethylamine is miscible in water at temperatures below 18.7 °C. When spilled, it will quickly disperse. Like most amines, triethylamine has an alkaline reaction with water resulting from the uptake of hydrogen ions by the nitrogen atom. Very high pH levels may sponsor the evolution of ammonia gas. No data are given on biodegradability, but triethylamine is not likely to persist for extensive periods of time.

Triethylamine is toxic to fish and fish food organisms. The critical range for creek chub has been identified as 50-80 ppm (1). Daphnia display a toxic threshold of 200 ppm while that for microregma is 90 ppm (1). The algae Scenedesmus is affected at 1 ppm (1).

Triethylamine is an ingestive and inhalative toxicant. The average oral LD50 for mammals falls in the range 400-499 mg/kg body weight (15). Consumption can lead to acute liver and kidney damage. Triethylamine is also a strong irritant which can cause damage upon contact. A TLV of 100 mg/m^3 has been established for the vapor in air.

NAME Triethylamine

PRODUCTION QUANTITY 5.6 million lbs-1969

COMMON SHIP OR CONTAINER SIZE 1-5 gal cans, 55 gal drums, tank cars

M.P. -114.7 °C

B.P. 89.4 °C

Sp.G. .729

SOLUBILITY Miscible

TOXICOLOGICAL

ppm	hrs	species	harm	cond	ref
20	24	Fish	Lethal		5
50-80	24	Chub	Critical Range	Aerated, 15-21°C	1
1	96	Scenedesmus	Toxic Threshold	24°C	1
200	48	Daphnia	Toxic Threshold	23°C	1
90	48	Microregma	Toxic Threshold	23°C	1
1000		E. Coli	No Effect		1

Mammalian

species	mg/kg B. W.	administration route	ref
Mammals	460-546	Oral	15
White Mouse	546-8	Oral	15
Rat	460	Oral	15

END

TRIMETHYLAMINE

Trimethylamine is used in organic synthesis, especially of choline salts; as a warning agent for gases, and in disinfectants, flotation, insect attraction, and the production of quarternary ammonium compounds and synthetic resins. The 21 million lbs produced in 1969 (199) were shipped as a solution in glass bottles, drums and tank cars, and as an anhydrous gas in cylinders and tank cars.

Trimethylamine is readily soluble in water. Spills of anhydrous gas may not result in large concentrations of dissolved amine because of poor interfacial contact, but spills of solution will rapidly disperse through the water column. Trimethylamine has an alkaline reaction with water resulting from the attachment of an acid radical to the nitrogen atom. Though no data are available, trimethylamine should be susceptible to moderately rapid biodegradation. Trimethylamine is a common product of putrifaction of plant and animal tissue.

Trimethylamine was found to kill rainbow trout in 14 minutes when present at 200 ppm (1). Its ability to raise solution pH further threatens aquatic life.

Trimethylamine is moderately toxic with ingestion or inhalation (38). The oral MLD for rabbits has been reported as 400 mg/Kg body (78) weight while mice have been killed by an intraperitoneal dose of 75 mg/Kg (237).

NAME Trimethylamine

PRODUCTION QUANTITY 21 million lbs-1969

SYNONYMS TMA

COMMON SHIP OR CONTAINER SIZE Solution: glass bottles, drums, tank cars
Anhydrous: Cylinders, tank cars

DOT (Anhydrous) Flammable Gas, Red Label, 300 lbs in outside containers
(Solution) Flammable Liquid, Red Label, 10 gal in outside container

USCG Inflammable gas or liquid, red label

M.P. -117.1 °C

B.P. 2.87 °C

Sp.G. 0.662 as liquid

SOLUBILITY 410,000 ppm at 25°C

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
268	.25	Rainbow Trout	Lethal	11-13.5°C pH 8.62	1

Mammalian

species	mg/kg B. W.	administration route	ref
Rabbit	400	Oral-MLD	78
Rabbit	800	Intravenous-MLD	78
Mouse	75	Intraperitoneal-LD	237

URANIUM

Uranium and uranyl salts in addition to their common use in the production of atomic energy are employed in photography, glazing and painting, and in chemical processes. Typically, shipments of these materials are small and well protected.

While elemental uranium is insoluble in water, many of its salts are freely soluble. Natural waters have been found to contain as much 0.139 mg/l uranium (56). Drinking water often contains .002 .05 mg/l (56). Such data indicates that uranium may persist once dissolved in water. Only the uranyl oxides are insoluble enough to suggest precipitation out to low levels.

Uranium has been found to be quite toxic to aquatic life when added in the uranyl salt form. The 96 hr Tlm for fathead minnows in soft water is reported as 2.8 ppm, 3.1 ppm, and 3.7 ppm with the sulfate, nitrate, and acetate, respectively. In hard water, the value increased to 135 ppm for the sulfate (1). Fish food organisms exhibit threshold effects in the range 1.7-28 ppm (1). Solution hardness is important in determing resulting toxicity. The algae Ochromonas is reported to concentrate uranium. Uranium can also be absorbed onto algal species but appears to be nontoxic to them (1). In salt water, Japanese investigators have found inhibition of fertilization processes leading to polyspermy in Urechis eggs at 250 ppm uranium (1).

Uranium is highly toxic aside from its natural radioactive properties. The oral LD50 for rabbits is reported as 400 mg/Kg body weight while that for rats is 2083 mg/Kg (56). Chronic feeding studies show marked renal damage in dogs fed 25 mg/Kg/day uranyl fluoride and 200 mg/Kg/day uranium fluoride (1). Diets containing 0.25-0.5 percent uranyl fluoride caused slight anemia in rats (1). The Division of Industrial Hygiene, Ontario Department of Health, suggests a maximum neutral uranium level of .5-1 mg/l for drinking water (1). Permissable surface water levels for the U.S. have been set at 5 ppm uranyl ion while the Soviet Union requires less than 0.6 ppm uranium in drinking water (56).

NAME Uranium

DOT Poison D, Radioactive Material, Red Label

M.P. 1133 °C

B.P. Ign.

Sp.G. 18.7

SOLUBILITY Insoluble

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
Uranyl Sulfate					
2.8	96	Fathead Minnow	TLm	pH 8.2, alk=18ppm, Hard=20ppm	1
135	96	Fathead Minnow	TLm	pH 8.2, alk=360ppm, Hard=400ppm	1
Uranyl Nitrate					
3.1	96	Fathead Minnow	TLm	pH 8.2, alk=18ppm, Hard=20ppm	1
Uranyl Acetate					
3.7	96	Fathead Minnow	TLm	pH 8.2, alk=18ppm, Hard=20ppm	1
Uranyl Nitrate expressed as Uranium					
13		Daphnia Magna	Threshold Effect	River Havel	1
22		Scenedesmus	Threshold Effect	River Havel	1
1.7-22		E. Coli	Threshold Effect	River Havel	1
28		Microregma	Threshold Effect	River Havel	1

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
250		Urchin Eggs	Inhibited Fertilization, Polyspermy		1

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	2063	Oral	50
Rabbit	400	Oral	56

URANIUM PEROXIDE

M.P. - Decomposes @ 115°C

SOLUBILITY - 6 ppm in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - UO_4 is generally stable, but if heated above 90-195°C forms the alternate peroxide U_2O_7 which decomposes in water to UO_3 and oxygen.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for uranium ion.

URANYL ACETATE

SYNONYMS - Uranium Oxyacetate, Bis (Acetato - O) Dioxo Uranium

M.P. - Loses water at 110°C

B.P. - Decomposes at 275°C

Sp. G. - 2.893 @ 15°C

SOLUBILITY - 76,940 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Solutions are acid. Buffering or neutralization will precipitate as uranium salt. Hardness reduces toxicity considerably.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Param	Cond.	Ref.
3.7	96	Fathead Minnow	TLm	Soft Water pH-7.4	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Mouse	400	Intraperitoneal	96

URANYL NITRATE

SYNONYMS - Uranium Oxynitrate, Bis (Nitrato - O) Dioxo Uranium Hexahydrate

M.P. 60.2°C

B.P. - Decomposes at 100°C

Sp. G. - 2.807

SOLUBILITY - 1,703,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Solutions are acid. Buffering or neutralization will precipitate uranium salts.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
3.1	96	Fathead Minnow	Tlm	Soft Water pH-7.4	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	135	Intraperitoneal	98

URANYL SULFATE (TRIHYDRATE)

SYNONYMS - Uranium Oxysulfate

M.P. - Decomposes at 100°C, anhydrous 300°C

Sp. G. - 3.28

SOLUBILITY - 205,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Forms acid solution. Buffering or neutralization leads to precipitation of uranium salts.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Test	Cond.	Ref.
2.8	96	Fathead Minnow	TLm	Softwater pH-7.4	1
135	96	Fathead Minnow	TLm	Hardwater pH-8.2	1

VANADIUM

Vanadium is commonly used as an additive to increase the hardness and malleability of steel. Vanadyl sulfate is the most important vanadium salt in commerce where it is used as a dye mordant and in glazing ceramics. It is shipped in glass bottles and kegs by rail and truck. Although large amounts (13 x 10^6 lbs in 1968) of vanadium ore are processed in the United States, it is believed a relatively minor portion of this goes into the sulfate, since the major use of vanadium is as a catalyst and in steel alloys which require other compounds.

Vanadium itself is insoluble, but common salts like vanadyl sulfate are not. Hence, spillage will result in dispersion of ionic vanadium through the water column. The insoluble hydroxide will be formed at neutral pH and above and consequently will both lower the pH and the vanadium levels. Natural dilution and buffer capacity will dictate low equilibrium vanadium concentrations.

Vanadium has been found toxic to aquatic life. The 96 hr TLm for fathead minnows in hard and soft water are 30 ppm and 4.8 ppm, respectively for vanadium added as vanadyl sulfate (230). Similar tests with bluegill gave the values 55 ppm and 6 ppm (230). Corresponding values with fathead minnows exposed to vanadium pentoxide were 11 ppm and 55 ppm as vanadium (1). A concentration of 0.1 mg/l stimulates growth of the algae Scenedesmus (1).

Vanadium can be quite toxic when ingested or inhaled. The median lethal dose to rats has been reported as 1 mg/kg bod[illegible]ght (15). Chronic feeding studies show biochemical changes in animals fed 1 mg/kg or more (15). On the other hand, 5 mg/l (0.5 and 0.7 mg/kg) of Va^{+4} ion to rats and mice for life had no effects on growth, survival, or longevity (15). The Soviet Union has placed a limit of 0.1 mg/l vanadium in drinking water. Tests with mice indicate 18 percent tumor development when fed 14.43 mg/l vanadyl sulfate for life in drinking water plus 0.21 mg/kg in diet (15). Vanadium fed to chicks as calcium vanadate inhibited growth at 20 mg/kg while the LD50 was 100-150 mg/kg as vanadium (1).

Vanadium can both enhance and retard growth in plants depending on its concentration. Solutions of 0.1 mg/l had no effect on soybeans or flax, while 10-20 mg/l can be harmful (1). A concentration of 50 mg/l vanadate ion was slightly injurious to sugar beets (1).

VANADIUM PENTOXIDE

SYNONYMS - Vanadic Anhydride, Vanadic Acid Anhydride

COMMON SHP'T OR CONTAINER SIZE - Drums, Multiwall Paper Sacks

M.P. 690°C

B.P. - Decomposes @ 1750°C

Sp. G. - 3.357 at 18°C

SOLUBILITY - 8000 ppm at 20°C

PERSISTENCE

Chemical Hydrolysis, etc. - Many vanadium salts are insoluble.

TOXICOLOGICAL

Freshwater Toxicity

PPM	hrs	Species	Form	Cond.	Ref.
13	96	Fathead Minnow	TLm	Softwater	1
55	96	Fathead Minnow	TLm	Hardwater	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Human	0.1 mg/m³/8 hr day	Inhalation - TC low	90

NAME Vanadyl Sulfate

SYNONYMS Minasragrite

COMMON SHIP OR CONTAINER SIZE Bottles kegs

SOLUBILITY Soluble

TOXICOLOGICAL

Salt Water Toxicity

ppm	hrs	species	[illegible]	[illegible]	ref
30	96	Fathead Minnow	TLm	Hard	219
4.8	96	Fathead Minnow	TLm	Soft	219
55	96	Bluegill	TLm	Hard	219
6	96	Bluegill	TLm	Soft	219

Mammalian

species	mg/kg B. W.	administration route	ref
Rat	1	Oral MLD as Vanadium	15

VINYL ACETATE

Vinyl acetate is used to produce plastics, lacquers, and film. The nearly 730 million lbs produced in 1969 (109) were shipped in cans, drums, tank cars, tank trucks, and tank barges.

Vinyl acetate is only partially soluble in water. When spilled, it will form a slick and dissolve slowly. Liquid exposed to sunlight will polymerize to an insoluble solid. Dissolved vinyl acetate will slowly degrade due to bacterial attack. As much as 42 percent of the theoretical oxygen demand may be utilized in the first 10 days (10). The rate of degradation will be too slow to cause oxygen sags in spill situations.

Vinyl acetate is considered toxic to fish. The 96 hr TLm for fathead minnows, bluegill, goldfish, and guppies have been reported as 22 ppm, 18 ppm, 42 ppm, and 36 ppm, respectively(37). In aerated salt water, shrimp display a 48 hr LC50 of 10-100 ppm, flounder greater than 100 ppm, and starfish 100-1000 ppm (8). The undissolved slick poses a hazard to waterfowl and marine mammals.

Health hazards have not been identified for vinyl acetate (30). The average oral LD50 for mammals falls in the range 1000-2400 mg/kg body weight (15). Direct contact may cause mild irritation. Vapors are narcotic at high concentrations and hence a TLV of 30 mg/m^3 has been established.

NAME Vinyl Acetate

PRODUCTION QUANTITY 730 million lbs - 1969

SYNONYMS Acetic Acid Ethylene Ester

COMMON SHIP OR CONTAINER SIZE Cans, drums, tank cars, tank trucks, tank barges

DOT Flammable Liquid, Red Label, 10 gal in outside container

USCG Grade C flammable liquid.

M.P. -93.2 °C

B.P. 72.5 °C

Sp.G. 0.9317

SOLUBILITY 20,000 mg/l at 20 °C

PERSISTENCE

Oxygen Demand

BOD10 = [illegible] Thod. with sewage seed from CO2 determinations - (10)
BOD10 = [illegible] Thod. from CO2 measurements - (26)
BOD10 = [illegible] Thod. with acclimated seed from CO2 determination - (26)
BOD20 = [illegible] Thod. from CO2 measurement - (26)
BOD5; 10; 15; 20 = [illegible] Thod. in freshwater - ([illegible])
BOD5; 10; 15; 20 = [illegible] Thod. acclimated - ([illegible])
BOD5; 10; 15; 20 = [illegible] Thod. in saltwater - ([illegible])

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	data	cond	ref
18	96	Fathead Minnow	TLm		37
18	96	Bluegill	TLm		37
42	96	Goldfish	TLm		37
39	96	Guppy	TLm		37

Salt Water Toxicity

ppm	hrs	species	data	cond	ref
10-100	48	Shrimp	LC50	Aerated	[illegible]
[illegible]	48	Flounder	LC50	Aerated	[illegible]
100-1000	48	[illegible]	LC50	Aerated	[illegible]
[illegible]	24	Brine Shrimp	TLm		[illegible]

Mammalian

species	mg/kg B. W.	administration route	ref
[illegible]	[illegible]	Oral	[illegible]
Rat	2920	Oral	[illegible]
Mouse	1613	Oral	[illegible]

XYLENE

Xylene is a commercial mixture of the three isomers, ortho-, meta-, and para-xylene. Uses include addition as a high-quality octane-blending agent in motor fuels, as a solvent and as a chemical raw material. The 4.4 billion lbs produced in 1971 (199) were shipped in glass bottles, 55 and 110 gallon metal drums, tank cars, tank trucks, and tank barges.

Xylene is practically insoluble in water. When spilled, it will form a colorless slick and dissolve very slowly. Xylene is slightly basic. Xylene is quite stable in water both to chemical and biological attack. Tests for biochemical oxygen demand have shown xylene non-responsive to sewage seed (11) and aniline acclimated activated sludge(5). High concentrations may actually affect biological systems adversely. A 0.1 percent level seriously retards sewage digestion.

Xylene is toxic to fish and fish food organisms. For ortho- and meta-xylene, 96 hr TLm values of 21,22,24, and 39 mg/liter were found for fathead minnows, bluegills, goldfish, and guppies, respectively in constant temperature water (17). A concentration of 5 ppm of the meta isomer had no effect on sea lamprey or rainbow trout, but caused illness in bluegill after 10 hrs (1). A 24 hour median tolerance limit range from 10-100 mg/l was found for the waterflea, Daphnia magna, in constant temperature water (59). The undissolved slick poses a threat to waterfowl and marine mammals.

Xylene is only slightly toxic (38). The oral LD50's for rats and white mice are 4000 mg/Kg body weight (8), and 4300 mg/Kg body weight (7), respectively. Low levels of xylene can be absorbed through skin. A concentration of 6000 ppm is lethal to mice in air (8).

Xylenes may cause detectable odors when present in waters at 0.26-4.13 ppm (38).

NAME Xylene

PRODUCTION QUANTITY 4.4 billion lbs in 1971

SYNONYMS Dimethyl Benzene

COMMON SHIP OR CONTAINER SIZE Bottles, 55 & 110 gal drums, tank cars, tank trucks, tank barges

DOT Flammable Liquid, Red Label, 10 gal in outside container

USCG Grade C, flammable liquid

M.P. -47.4 °C

B.P. 139.1 °C

Sp.G. 0.8684

SOLUBILITY Insoluble

PERSISTENCE

Oxygen Demand

BOD_5 = 0 lb/lb using sewage seed-(11)
BOD_5 = 0% Theo. with aniline acclimated activated sludge-(5)

TOXICOLOGICAL

Fresh Water Toxicity

Meta

ppm	hrs	species	[illegible]	cond	ref
5	24	Rainbow Trout	No Effect	Lake Huron Water	1
5	24	Sea Lampreys	No Effect	Lake Huron Water	1
5	24	Bluegill Sunfish	Illness	Lake Huron Water	1

Meta, Ortho, & Para

ppm	hrs	species	[illegible]	cond	ref
10-100	24	Daphnia Magna	TLm	Temp. Con.	59
21	96	Fathead Minnow	TLm	Temp. Con.	37
22	96	Bluegill	TLm	Temp. Con.	37
24	96	Goldfish	TLm	Temp. Con.	37
30	96	Guppy	TLm	Temp. Con.	37

Para

ppm	hrs	species	[illegible]	cond	ref
22-66	1	Sunfish	Lethal		109

species	mg/kg B. W.	administration route	ref.
Rat	4000	Oral	9
White Rat	4300	Oral	7

XYLENOL

Xylenol, dimethyl phenol, is a white crystalline chemical used in significant amounts in manufacture of disinfectants and resins. It occurs as isomers, of which the most reactive is 3,5 xylenol. The 14.6 million lbs produced in 1968 (199) were shipped in a wide variety of containers.

Xylenols are only slightly soluble in water. When spilled, they will seek the bottom and dissolve slowly. Phenols are typically quite susceptible to oxidation in the presence of air. This process is accelerated in basic solutions. Xylenols are also quite susceptible to chlorination which results in the production of compounds that exhibit much lower taste and odor thresholds. Dissolved xylenol is subject to biodegradation. As much as .85-1.5 lbs of oxygen per lb of xylenol may be utilized in 5 days time (11). This rate may be sufficient to produce oxygen sags in spill situations.

Data on various xylenols indicate that they are quite toxic to fish. Toxic action appears to occur in the range 4-75 ppm (1). The 24 hr Tlm for tench exposed to 1,2,4-xylenol is 17.8 ppm (1). Similar values for the 1,3,4; 1,3,5; and 1,4,5 forms are 13 ppm, 51.5 ppm, and .9 ppm, respectively.(1) While carp sperm and fish eggs are reported to be more tolerant than adult fish, salmonide embryos display a 24 hr Tlm value of 2 ppm (1). Fish food organisms appear more resistant than fish. Various threshold levels fall in the range 10-100 ppm (1). Bandt reports toxic effects from 1,3,4 xylenol occur at 77 mg/l for ciliates and rotatoria, 46 mg/l for crustacea, 108 mg/l for molluscs, and 154 mg/l for mastigophora (1). The algae *Chlorella pyrenoidosa* is affected at 40-81 ppm (4). Phenols in general are toxic to aquatic plants at 0.2 ppm (1), but 50 ppm xylenol had no effect on the photosynthetic oxygenation of algae (6). Waterfowl may be damaged if phenol levels exceed 25 ppm (41). The presence of 1 ppm in water may add tastes to fish flesh (1).

Xylenols can be highly toxic by all routes of administration. The oral LD50 values for rats fed the 2,6 and 3,4 isomers have been reported as 296 and 727 mg/kg body weight, respectively (241). Phenols in general should not be present above .001 ppm in drinking water (1). This level is predicated on organoleptic properties, however. Xylenols have a lower taste threshold at that level (1).

Xylenol can be absorbed through skin at toxic levels. Phenols in general should not exceed 10 ppm in fresh water (40) or 1 ppm in salt water (41), when prolonged body contact is likely to occur. Irrigation water should be limited to 20 ppm phenols if intended for use on vegetables (41).

NAME Xylenol

PRODUCTION QUANTITY 14.6 million lbs-1969

SYNONYMS Dimethyl Phenol, Hydroxydimethyl Benzene

M.P. 64 °C

B.P. 219.5 °C

Sp.G. 1.04

SOLUBILITY Slightly soluble

PERSISTENCE

Oxygen Demand

BOD_1 = 4.6% Theo. on 2,4 isomer (5)
1.4% Theo. on 2,6 isomer (5)
6.4% Theo. on 3,4 isomer (5)
2.4% Theo. on 3,5 isomer (5)
BOD_5 = 31% Theo. (126)
BOD_5 = sewage seed .82 lb/lb-1,3,5 isomer (11)
1.5 lb/lb-1,3,4 isomer (11)

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	[illegible]	cond	ref
77		Rotatoria, ciliates	Toxic		1
46		Crustacea	Toxic		1
106		Mollusca	Toxic		1
154		Mastigophora	Toxic		1
49-81		Chlorella Pyrenoidosa	Toxic		1
		1,2,4-xylenol (m-xylenol)			
4.0	24	Salmonids, Embryos	TLm	11°C	1
5.0		Bream, Bleak	Threshold of Toxicity		1
10		Carp	Threshold of Toxicity		1
11		Perch	Lower Toxic Limit		1
17.8	24	Tench	TLm	18°C	1

ppm	hrs	species	param	cond	ref
20	1	Minnows	Lethal Limit		1
21.1	48	Carp	TLm	9°C	1
26	.16	Perch	Lethal Limit		1
1,3,4-xylenol (o-xylenol)					
4		Perch	Lower Toxic Limit		1
8		Bream, Bleak	Threshold of Toxicity		1
10		Carp	Threshold of Toxicity		1
12	24	Tench	TLm	18°C	1
16	.16	Perch	Lethal Limit		1
20	.16	Minnows	Lethal Limit		1
27.7	24	Embryos	TLm	12°C	1
30	24	Carp	TLm	18°C	1
1,2,5-xylenol (p-xylenol)					
2		Perch	Lower Toxic Limit		1
5		Bream, Bleak	Threshold of Toxicity		1
10		Carp	Threshold of Toxicity		1
12	.16	Perch	Lethal Limit		1
20	.1	Minnows	Lethal Limit		1
20	.5	Rols	Lethal Limit		1
1,2,6-xylenol					
7-8		Trout	Toxic Level		1
1,3,5-xylenol					
15		Perch	Threshold of Toxicity		1
18		Bleak	Threshold of Toxicity		1
20		Bream	Threshold of Toxicity		1
50	24	Salmonide Embryos	TLm	13°C	1
51.5	24	Tench	TLm	18°C	1
53	24	Carp	TLm	18°C	1
70	4.5	Roach	Lethal	9°C	1
1,4,5-xylenol					
2	24	Salmonide Embryos	TLm	13°C	1
8	24	Tench	TLm	18°C	1
10	24	Carp	TLm	18°C	1
15	4.5	Roach	Lethal	11°C	1

ppm	hrs	species	parm	cond	ref
1,2,4-xylenol					
32	[illegible]	Daphnia	Threshold	River Havel	1
40	[illegible]	Scenedesmus	Threshold	River Havel	1
70	[illegible]	Microregma	Threshold	River Havel	1
>100	[illegible]	E. Coli	Threshold	River Havel	1
1,3,4-xylenol					
16	[illegible]	Daphnia	Threshold	River Havel	1
40	[illegible]	Scenedesmus	Threshold	River Havel	1
70	[illegible]	Microregma	Threshold	River Havel	1
600	[illegible]	E. Coli	Threshold	River Havel	1
1,2,5-xylenol					
16	[illegible]	Daphnia	Threshold	River Havel	1
40	[illegible]	Scenedesmus	Threshold	River Havel	1
50	[illegible]	Microregma	Threshold	River Havel	1
>100	[illegible]	E. Coli	Threshold	River Havel	1

Mammalian

species	mg/kg B. W.	administration route	ref
Mice	1070	Oral	240
Rat	296	Oral-2,6 isomer	241
Rat	727	Oral-3,4 isomer	241
Guinea Pig	1750	Subcutaneous MLD	4

Zectran

Zectran is a carbamate insecticide and acaricide used to control a wide range of pests including foliage feeding insects and mites, snails, and slugs on turf, shade trees, and shrubs. It is applied as an emulsifiable concentrate, or a wettable powder.

Zectran is a crystalline material soluble to 100 ppm in water. It is considered moderately resistant to biodegradation, and like other carbamates may produce carcinogenic materials when metabolized.

Zectran is moderately toxic to aquatic life. The 96 hour LC_{50} values for most common fish fall in the range 1.73-19.14 ppm.[11] Fish food organisms appear more sensitive. The 48 hour LC_{50} values for Daphnia pulex, P. californica, and Gammarus lacustris are 0.01 ppm, 0.010 ppm, and 0.076 ppm respectively.[11] In saltwater, the 24 hour EC_{50} to shrimp is reported as 0.0088 ppm while 1 ppm has no effect on oysters or longnose killifish.[111]

Zectran is quite toxic to higher forms of life. The oral LD_{50} for rats is 19 mg/kg body weight.[11] Oral LD_{50} values for common game birds fall in the range 1-10 mg/kg body weight.[11]

ZECTRAN

SYNONYMS - 4-Dimethylamino-3,5-Xylyl N-methylcarbamate

M.P. 85°C

SOLUBILITY - 100 ppm @ 25°C

PERSISTENCE

Oxygen Demand - Moderately persistent

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Para	Cond.	Ref.
8	48	Rainbow Trout	LC_{50}		22
1.73	96	Coho Salmon	LC_{50}		22
2.48	96	Yellow Perch	LC_{50}		22
8.1	96	Brown Trout	LC_{50}		22
10.2	96	Rainbow Trout	LC_{50}		22
11.2	96	Bluegill	LC_{50}		22
11.4	96	Channel Catfish	LC_{50}		22
13.4	96	Carp	LC_{50}		22
16.7	96	Largemouth Bass	LC_{50}		22
16.7	96	Black Bullhead	LC_{50}		22
16.7	96	Redear Sunfish	LC_{50}		22
17.0	96	Fathead Minnow	LC_{50}		22
19.14	96	Goldfish	LC_{50}		22
0.032	24	P. Californica	LC_{50}		58
0.086	24	Gammarus Lacustris	LC_{50}		22
0.01	48	Daphnia Pulex	LC_{50}		22
0.018	48	P. Californica	LC_{50}		22
0.076	48	Gammarus Lacustris	LC_{50}		22
0.013	48	Simocephalus Serrulatus	EC_{50}		22
0.010	48	Daphnia Pulex	EC_{50}		22
0.010	96	P. Californica	LC_{50}		402

Saltwater Toxicity

0.0008	96	Shrimp	LC_{50}	28°C	408
1.0	96	Oyster	No Effect	18°C	408
1.0	96	Longnose Killifish	No Effect		408

MAMMALIAN TOXICITY

Species	mg/kg B. W.	Administration Route	Ref.
Rat	10	Oral	[illegible]
Dog	15-30	Oral	[illegible]
Goat	15-30	Oral	[illegible]
Mule Deer	20-30	Oral	[illegible]

Avian Toxicity

Young Mallards	3.7	Oral	[illegible]
Pheasants	4.5	Oral	[illegible]
Young Chukar Partridges	5.2	Oral	[illegible]
Young Coturnix	3.2	Oral	[illegible]
Sharp-Tailed Grouse	10	Oral	[illegible]
Pigeons	6.5	Oral	[illegible]
Young Mourning Doves	2.0	Oral	[illegible]
House Sparrows	50.4	Oral	[illegible]
House Finches	4.8	Oral	[illegible]
Canada Geese	2.6	Oral	[illegible]
Lesser Sandhill Cranes	1-4.5	Oral	[illegible]

Amphibian Toxicity

Bullfrogs	203-800	Oral	[illegible]

ZINC

Zinc is one of the most common heavy metals found in fresh water. Kopp and Kroner reported that of 1577 surface water analyses zinc was detected in 76.5 percent of the samples and in those samples the zinc concentration ranged from 2 to 1183 mg/l. (253) Zinc is found in seawater in a concentration of 0.01 mg/l. (42) Zinc is introduced into the environment in wastes from mining and ore processing; in liquid wastes from the metal plating industry; and from the manufacture of organic materials such as acrylic fibers, rayon, and cellophane.

Most of the salts of zinc are shipped in cartons, barrels, boxes and drums by rail and truck.

Zinc salts (sulfate, chloride, and nitrates) are very soluble in distilled water. In natural water, however, the solubility is greatly dependent on pH, hardness and alkalinity. Bryan reports a concentration of 1.2-2.5 mg Zn/l in a saturated solution of sea water and indicates that $ZnCO_3$ is the possible form of precipitate (246).

As little as 0.1 mg/l of zinc will cause an effect upon biochemical oxygen demand and 62.4 mg/l will cause a 50 percent drop in the five day BOD (1). The maximum level of zinc which will not produce a significant effect on treatment efficiency of activated sludge plants is between 2.5-10 mg/l.

Mount has shown the uptake and accumulation of zinc by different tissues of the bluegill and found very little accumulation in muscle (247). Uthe & Bligh found that zinc concentrations of dressed samples of several species of fish varied from 11-30 ppm (wet weight). (248) Pequegnat et al. summarizes measured concentrations of zinc in marine plants and animals and states that there is considerable variation among organisms but in all cases zinc is much higher than the calculated zinc requirements.

Many environmental variables influence the toxicity of zinc to aquatic life. The form of the metal in water is important. Whether or not a complex form of zinc is less or more toxic seems to depend on its stability and how easily it can dissociate and give up the metal to the absorptive system of the organism. Mount found that with continuous-flow testing at 3 pH levels (6,7,8) and 3 total hardness levels (50, 100, 200) zinc was more toxic at a pH of 8 and a hardness of 50 mg/l, and least toxic at pH 6 and a hardness of 200 mg/l. At any given hardness zinc was always more toxic at a higher pH than at a lower ph. Precipitated zinc was shown to contribute to toxicity. The 96 hr TL50 values ranged from 0.7 to 33.5 mg Zn/l. (249) Pickering and Henderson found that for four species of warm water fishes tested in soft water (20 mg/l $CaCO_3$) the 96 hr TL50 values varied from about 1 mg Zn/l for the fathead minnow to 6 mg Zn/l for the goldfish. (250) Sprague found that for rainbow trout the threshold avoidance level was 5.6 mg Zn/l above the natural background level. (251) In a chronic toxicity study of the fathead minnow in hard water (200 mg/l) Brungs found that 0.18 mg Zn/l decreased egg production to only 17 percent of the control fish. Biesinger & Christensen found that the 48 hr LC50 for Daphnia magna in soft water (47 mg/l) with food was 0.03 mg Zn/l and a concentration of 0.1 caused a 50 percent reproduction impairment. (252)

Portman found zinc toxic to various marine organisms. The 48 hr LC50's for prawn, shrimp, cockles, crabs and oysters are reported as 0.5 ppm, 110 ppm, 257.5 ppm, 14.5 ppm, and 116.5 ppm when added as zinc sulfate. (3) A concentration of 157-180 ppm is lethal to mummichogs in 24-48 hrs. (254) In general, the threshold concentration for fish is 0.1 ppm Zn. (41)

Although zinc is an essential nutrient for plants, McKee & Wolf list 3 mg Zn/l as toxic to oranges, 5 mg Zn/l as toxic to flax, and 25-100 mg Zn/l toxic to oats (1). For irrigation purposes, zinc content should not exceed 5.0 ppm (40).

Zinc is also an essential element in the nutrition of man, but can be toxic in high concentrations. The lethal dose of various salts depends in part on the anion. The oral LD50 for rats fed the chloride is 350 mg/kg body weight (15) while that for the acetate is 2400 mg/kg (1) and the nitrate is 2500 mg/kg. (85) Large doses to humans can have corrosive action on digestive membranes. (15) Lethal doses of 6000 mg zinc chloride and 45,000 mg zinc sulfate have been reported in humans. (15) Chronic feeding studies utilizing 0.96-1.92 percent zinc carbonate for 30 weeks in rats and 8-16 mg zinc sulfate in dogs, rats, cats, frogs, and snails have shown significant effects on cardiac and blood functions. (15)

Zinc can produce a bitter taste in water at 5.0 ppm and hence is maintained below that level for drinking water. (1)

NAME Zinc

PRODUCTION QUANTITY Chloride Salt - 83.8 million lbs. - 1969
Sulfate salt - 64.6 million lbs. - 1971

COMMON SHIP OR CONTAINER SIZE Barrels, bags, boxes, drums

M.P. 419.4 °C

B.P. 907 °C

Sp.G. 7.14

SOLUBILITY Common salts are soluble

PERSISTENCE

Chemical Hydrolysis, Etc.

Carbonate will precipitate out.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
0.43	24	Cutthroat Trout	TLm	Flowing	256
.0056	-	Rainbow Trout	Avoidance	Soft	257
46	24	Tubificid Worms	TLm	pH 7.5	258
12	96	Platyfish	TLm	-	259
7.6	96	Fathead Minnow	TLm	-	259
0.2	96	Fathead Minnow	TLm	Continuous Flow	260
1	-	Snail	Toxic	Natural H_2O	
.05-.1	-	Snail	Toxic	Distilled	1
.79-1.27	96	Pond Snail	TLm	Soft Temp. 20 °C	1
.62-.78	96	Pond Snail	TLm	Soft Temp. 30 °C	1
2.67-5.57	96	Pond Snail	TLm	Hard Temp. 20 °C	1
3.36-6.36	96	Pond Snail	TLm	Hard Temp. 30 °C	1
2.86	-	Bluegill	TLm	18 °C Soft	170
0.9	-	Bluegill	TLm	30 °C Soft	170
8.6	-	Bluegill	TLm	18 °C Hard	170
6.18	-	Bluegill	TLm	30 °C Hard	170
1-10	-	Micro life	Lethal	-	209
1.0	-	Magna	Threshold	-	61
.3		Mayfly Nymphs	Lethal	-	61

ppm	hrs	species	parm	cond	ref
0.03	96	Heliosoma Campanulatum	TLm	13 °C Hard	109
0.07	96	Heliosoma Campanulatum	TLm	13 °C Soft	109
.6	–	Salmo Salar	Incipient Lethal	–	109
0.05	–	Atlantic	Avoidance	Lab. Water	109
0.01	–	Trout Ova and Young	Lethal	–	1
0.01-0.4	–	Young Rainbow Trout	Lethal	–	1
0.11	12-24	Rainbow Fingerlings	Lethal	–	1
0.15	–	Guppy	Lethal	–	1
0.15	–	Salmon Fry	Lethal	–	1
0.2	–	Trout	Lethal	Soft	1
0.3	–	Mature Fish	Lethal	–	1
0.3-0.7	–	Sticklebacks	Lethal	–	1
0.4	–	Fish	Lethal	Soft	1
0.5	6 Days	Fish	Lethal	–	1
0.5	–	Mixed Warm-Water Fish	Lethal	Soft	1
0.5	3 Days	Fingerling Rainbow Trout	Lethal	Soft	1
0.65	3 Days	Rainbow Trout	Lethal	–	1
1.0	12	Dace	Lethal	Soft	1
1.3-3.6	24	Sticklebacks	Lethal	Soft 30 °C	1
2.0	96	Bluegill Sunfish	TLm	Soft	1
2.9-3.0	10	Fish	Lethal	Soft 20 °C	1
3.0	96	Bluegill Sunfish	TLm	Soft	1
3.0	5	Fingerling Rainbow Trout	Lethal	–	1
3.5	48	Rainbow Fry	Lethal	Soft 30 °C	1
3.5	96	Bluegill Sunfish	TLm	Std. dil. Water 20 °C	1
	96	Bluegill Sunfish (medium)	TLm	–	1
4.0	3 Days	Rainbow Trout	Lethal	Hard	1
4.2	96	Bluegill Sunfish	TLm	Soft 20 °C	1
5-15	–	Fish	Lethal	–	1
6.0	48	Young Trout	Lethal	–	1
8.0	5	Fish	Lethal	Soft	1
8.02	96	Bluegill Sunfish	TLm	Std. dil. Water	1
9.11	–	Trout	Lethal	–	1
10.1-12.5	96	Bluegill Sunfish	TLm	Hard 18 °C and 30 °C	1
12.5-12.9	96	Bluegill Sunfish	TLm	Hard 20 °C and 30 °C	1

ppm	hrs	species	parm	cond	ref
12.0	8	Fish	Lethal	–	1
20.0	16	Fish	Lethal	Soft	1
25-50	2	Rainbow Trout	Lethal	[illegible]	1
200	2.5	Fish	Lethal	Soft	1
0.003	28 Days	Rainbow Alevins	Safe	–	1
0.003	20 Days	Brown Trout Fingerlings	Safe	–	1
0.13	20 Days	Brown Trout Fingerlings	Safe	Hard	1
1.0	10 Days	Sticklebacks	Safe	Hard	1
3.0	2 Days	Mature Fish	Safe	Hard	1
2.0-3.5	14 Days	Rainbow Trout	Safe	Hard	1
3.0	10 Days	Fingerling Rainbow Trout	Safe	Hard	1
4.0	48	Young Trout	Safe	–	1
8.0-11.0	–	Some Individual Trout	Safe	–	1

Salt Water Toxicity

ppm	hrs	species	parm	cond	ref
157-180	24-48	Mummichogs	Lethal	20 °C	254
[illegible] Sulfate					
7.5	48	Prawn	LC_{50}	Aerated	2
110	48	Shrimp	LC_{50}	Aerated	2
257.5	48	Cockle	LC_{50}	Aerated	2
14.5	48	Crab	LC_{50}	Aerated	2
116.5	48	Oyster	LC_{50}	Aerated	2

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	75	Intravenous-chloride	8
Rat	2500	Oral-Nitrate	85
Rat	60	Intraperitoneal-Sulfate	
Mice	13	Intraperitoneal-Sulfate	88
Rat	2400	Oral-Acetate	1
Rat	350	Oral-Chloride	15
Mice	350	Oral-Chloride	15
Guinea Pig	350	Oral-Chloride	15

ZINC ACETATE

COMMON SHIP OR CONTAINER SIZE = Bottles, Cartons, Fiber Drums, Car lots (also available in solution

M.P. 237°C

B.P. $-H_2O$ at 100°C

Sp. G. = 1.735 (dihydrate), 1.84

SOLUBILITY = 310,000 ppm in cold water

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Zinc may be precipitated as carbonate and hydroxide salt. Acetate is biochemically oxidized.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
0.88	96	Fathead Minnow	TLm	Soft	76

Mammalian Toxicity

Species	mg/kg B. W.	Administration	Ref.
Rat	2460	Oral	77

ZINC AMMONIUM CHLORIDE

Sp.G. - 1.8

SOLUBILITY - Soluble in water

PERSISTENCE - Zinc can persist indefinitely as a cation

TOXICOLOGICAL

FRESHWATER TOXICITY - Toxicity is that for zinc ion

ZINC BORATE

M.P. 980°C

Sp. G. = 3.64 amorphous, 4.22 as crystal

SOLUBILITY = Soluble in cold water

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates to zinc and borate ions. Zinc may precipitate as carbonate or hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for zinc ion except for the case of plant life where borate ions can be influential.

ZINC BROMIDE

M.P. 394°C

B.P. 650°C

Sp. G. = 4.219 at 4°C

SOLUBILITY = 4,470,000 ppm at 20°C

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Zinc may be precipitated as carbonate or hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for zinc ion.

ZINC CARBONATE

SYNONYMS - Smithsonite

M.P. - loses CO_2 at 300°C

Sp. G. - 4.42

SOLUBILITY - 10 ppm in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - May be converted to less soluble hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for zinc ion.

7yD=

ZINC CHLORIDE

SYNONYMS = Butter of zinc

COMMON SHIP OR CONTAINER SIZE = Bottles, Drums, Solution in Tank Cars and Tank Trucks

M.P. 290°C

B.P. 732°C

Sp. G. = 2.907

SOLUBILITY = 4,320,000 at 25°C

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Zinc will precipitate as carbonate and hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
1	24	Young Carp	Killed	Tap	1
.14	>50	Young Eels	Maximum Tolerated		1
.65	12	Young Eels	Killed		1
7.2	96	Bluegills	TLm	20°C	1
15	8	Fish	Killed		1
17.1	1	Minnows	No Effect	Tap	1
.17	24	Harlequin Fish	LC_{50}		22
5.35	96	Bluegill	TLm	Soft	76
8.02	96	Bluegill	TLm	Normal D	1
4.9	96	Bluegill	TLm	DO-2ppm	1
1.38	>120	Daphnia Magna	Killed		1
<.15	-	Daphnia Magna	Immobilized	Lake Erie	1

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
20	48	Zebrafish	TLm	24°C	424

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	75	Intravenous	8
Chicken (Bird)	1	Parenteral-TD_{LO}	96
Rat	350	Oral	442

ZINC FLUORIDE

M.P. 872°C

B.P. 1497°C

Sp. G. = 4.955 @ 15°C

SOLUBILITY = 16,000 ppm for tetrahydrate

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates upon dissolution. Hydroxide and carbonate zinc salts precipitate as does calcium fluoride.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for fluoride ion.

Saltwater Toxicity - Toxicity will be that for zinc ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Guinea Pig	200	Oral-Low Lethal Dose	98
Guinea Pig	100	Subcutaneous-Low Lethal Dose	98

ZINC FORMATE

B.P. = Decomposes

Sp. G. = 2.20

SOLUBILITY = 52,000 ppm @ 20°C

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Hydroxide and carbonate salts of zinc will precipitate while formate is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for zinc ion.

ZINC HYDROSULFITE

SYNONYMS = Zinc Dithionite

SOLUBILITY = Soluble

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Hydroxide and carbonate salts of zinc precipitate while hydrosulfite ion oxidizes to sulfate.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for zinc ion.

ZINC NITRATE

COMMON SHIP OR CONTAINER SIZE - Drums, carlots

DOT - Oxidizing Material, yellow label, 100 pounds

USCG - Oxidizing Material

IATA - Oxidizing Material, yellow label, 12 kg passenger, 45 kg cargo

M.P. 36°C

B.P. 105°C loses $6H_2O$

Sp. G. = 2.07

SOLUBILITY - 1,840,000 ppm @ 20°C

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Hydroxide and carbonate salts of zinc will precipitate.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
1.89	3 mo.	Tadpoles	Survived, no limb buds		1
5.7		Tadpoles	Killed most		1
94.7		Tadpoles	Killed quickly		1
100	15	Daphnia magna	Killed		1
0.87		Stickleback	Toxic Threshold		1

Saltwater Toxicity

ppm	hrs	Species	Form	Cond.	Ref.
12	48	Barnacles	90% Lethal		406

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	2500	Oral	85

ZINC PHENOLSULFONATE

SYNONYMS - Zinc 1-Phenol 4-Sulfonate, Zinc Sulfocarbolate

COMMON SHIP OR CONTAINER SIZE - Glass Bottles, Drums

M.P. 125°C losses $8H_2O$

SOLUBILITY = 625,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Zinc will precipitate as hydroxide and carbonate salts. Phenolsulfonate is degradable leaving residual sulfate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for zinc ion.

ZINC PHOSPHIDE

COMMON SHIP OR CONTAINER SIZE - Tins, Glass Bottles

IATA - Class B Poison, Poison label, 25 kg passenger, 5 kg cargo

M.P. 420°C

B.P. 1100°C

Sp. G. = 4.55 @ 13°C

SOLUBILITY - Insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Zinc may precipitate as hydroxide and carbonate salt. Phosphide will oxidize to phosphate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for zinc ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	41	Oral	96
Rat	45.7	Oral	8

ZINC POTASSIUM CHROMATE

SOLUBILITY - Insoluble

PERSISTENCE

Chemical Hydrolysis, etc. - Zinc precipitates as hydroxide and carbonate salts.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for zinc ion.

ZINC SILICOFLUORIDE

SYNONYMS = Zinc Fluosilicate

M.P. = Decomposes on heating

Sp. G. = 2.104

SOLUBILITY = Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. = Dissociates in water. Zinc will precipitate as hydroxide and carbonate salts.

TOXICOLOGICAL

Freshwater Toxicity = Toxicity will be that for zinc ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	100	Oral-Low Lethal Dose	96
Guinea Pig	100	Oral-Low Lethal Dose	96
Guinea Pig	200	Subcutaneous-Low Lethal Dose	96

ZINC SULFATE

SYNONYMS - White Vitriol, Zinc Vitriol, Goslarite, Zinkosite

COMMON SHIP OR CONTAINER SIZE - Glass Bottles, Barrels, Fiber Drums, Multiwalled Paper Sacks

M.P. 38°C loses H_2O and again at 280°C

B.P. - Decomposes at 740°C

Sp. G. - 1.97

SOLUBILITY - 965,000

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates in water. Zinc precipitates as hydroxide and carbonate salts.

TOXICOLOGICAL

ppm	hrs	Species	Parm	Cond.	Ref.
1000	1-4	Goldfish	Lethal	hard	
13.4	96	Helisoma Campanulaturm	Tlm	13°C, hard	109
3.05	96	Helisoma Campanulaturm	Tlm	13°C, soft	109
9.2	96	Fathead Minnow	Tlm		407
6	96	Rainbow Trout Fingerlings	Lethal		109
<404	-	Minnow	Lethal		145
.3 as Zn	-	Stickleback	Lethal		1
0.13 as Zn		Guppy	Lethal		1
0.3 as Zn	Long Term	Stickleback	Lethal		1
0.4 as Zn	168	Stickleback	Lethal		1
0.7 as Zn	96	Stickleback	Lethal		1
0.8	2.5	Minnows	Lethal		1
1.5	24	Stickleback	Lethal	Soft	1
3-6 as Zn	48	Young Trout	Lethal	Tap	1
4.0	2.51	Minnows	Lethal		1
6.0 as Zn	14	Trout Fingerlings	Lethal	Tap	1
8.1	1.25	Minnow	Lethal		1
10		Fish	Lethal	Fresh	1
10	30	Trout	Lethal		1
10	48	Minnow	Lethal	Fresh	1
16	20	Young Eels	Lethal		1
25	21	Rainbow Trout	Lethal	Distilled	1

ppm	hrs	Species	Parm	Cond.	Ref.
25-50 as Zn	2	Rainbow Trout	Lethal	Tap	1
100	120	Goldfish	Lethal		1
400	3.3	Minnow	Lethal	Distilled	1
1000	1	Goldfish	Lethal	Hard	1
2.0 as Zn	24	Young Trout	Safe		1
2.5-3.5 as Zn	336	Rainbow Trout	Safe	Hard	1
4.0 as Zn	24	Old Trout	Safe		1
100 as Zn Sulfate	96	Fish	Safe	Hard	1
200 as Zn Sulfate		Minnows	Safe	Fen	1
1000 as Zn Sulfate	24	Trout	Safe		1

Saltwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
0.16		Sea Urchin Eggs	Abnormal		1
20	48	Atlantic Salmon	TLm		408
20	48	Rainbow Trout	TLm		408
9.5	48	Prawn	LC_{50}	Aerated	2
110	48	Shrimp	LC_{50}	Aerated	2
257.5	48	Cockle	LC_{50}	Aerated	2
14.5	48	Crab	LC_{50}	Aerated	2
116.5	48	Oyster	LC_{50}	Aerated	2

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	40	Intraperitoneal	96
Mice	12	Intraperitoneal	96

ZINC SULFATE, MONOHYDRATE

M.P. - Refer to Zinc Sulfate

B.P. - Refer to Zinc Sulfate

Sp.G. - Refer to Zinc Sulfate

SOLUBILITY - Soluble in water

PERSISTENCE - Zinc can persist indefinitely as a cation.

TOXICOLOGICAL

FRESHWATER TOXICITY - Toxicity will be that for zinc ion,

ZIRCONIUM

Zirconium, though often considered a rare metal, is present in the earth's crust to a greater extent than copper, lead, or zinc. It is used in metallurgy to improve the wear resistance of alloys, in electronics, in nuclear reactors for shielding, in tanneries, and in pigmentation. Common salts include the chloride, nitrate, and sulfate.

While the chloride, nitrate, and sulfate are quite soluble (sulfate-525,000 ppm), the silicate, hydroxide, oxide, and carbonate are insoluble. Hence, though soluble when spilled, zirconium salts do not persist in that form due to the deposition of the insoluble forms.

Zirconium toxicity to fish depends largely on solution hardness. Whereas the 96 hr TLm for fathead minnows is 14 ppm zirconium sulfate in soft water, the same value is 115 ppm in hard water (1). Similarly, the value for the oxychloride goes from 18 ppm in soft water to 240 ppm in hard water (1).

Zirconium displays a low order of toxicity to mammals. In feeding studies of up to two yrs duration, 20 percent zirconium oxide in rats' diets had no effect (1). The oral LD50 values for salts fed to rats have been reported as 851 mg/kg body weight for the nitrate (1), and 1251 mg/kg for zirconium sulfate (129).

NAME Zirconium

M.P. 1900 °C

B.P. >2900 °C

Sp.G. 6.4

SOLUBILITY Insoluble

PERSISTENCE

Chemical Hydrolysis, Etc.

Silicates, oxides and hydroxide are relatively soluble.

TOXICOLOGICAL

Fresh Water Toxicity

ppm	hrs	species	parm	cond	ref
Zirconium Sulfate					
14	96	Fathead Minnow	TLm	Soft	1
115	96	Fathead Minnow	TLm	Hard	1
Zirconium Oxychloride					
18	96	Fathead Minnow	TLm	Soft	1
240	96	Fathead Minnow	TLm	Hard	1
15	96	Bluegill	TLm	Soft	1
270	96	Bluegill	TLm	Hard	1

Mammalian

species	mg/kg B.W.	administration route	ref
Rat	853	Oral-Nitrate	1
Rat	2290	Oral-Sodium Zirconyl Sulfate	1
Rat	1253	Oral-Zirconium Sulfate	129
Rabbits	150	Intravenous-Death, Zirconium Sulfate	18

ZIRCONIUM ACETATE

SYNONYMS - Diacetatozirconic Acid

COMMON SHIP OR CONTAINER SIZE - 500 lb Drums, 30,000 lb Carloads

Sp. G. - 1.46 @ 22% ZrO_2, 1.20 @ 13% ZrO_2

SOLUBILITY - Soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Zirconium hydroxide salt precipitates. Acetate is biodegradable.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity is that for zirconium ion.

ZIRCONIUM POTASSIUM FLUORIDE

SOLUBILITY - Soluble

PERSISTENCE

Chemical Hydrolysis - Dissociates in water. Zirconium ions will precipitate as hydroxide salt, fluoride ions as calcium salt.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for fluoride anion.

Saltwater Toxicity - Toxicity will be that for zirconium ion.

ZIRCONIUM NITRATE

USCG - Oxidizing Material, yellow label

IATA - Oxidizing Material, yellow label, 12 Kg Passenger, 45 Kg cargo.

M.P. - Decomposes at 100°C

SOLUBILITY - Very soluble

PERSISTENCE

Chemical Hydrolysis, etc. - Zirconium hydroxide salt will precipitate.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for zirconium ion.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	851	Oral	96

ZIRCONIUM OXYCHLORIDE

SYNONYMS - Zirconyl Chloride, Basic Zirconium Chloride

COMMON SHIP OR CONTAINER SIZE - Barrels, 250 lb Fiber Drums,
10,000 lb Carloads

M.P. 150°C loses 6 H_2O, 8H_2O @ 210°C

SOLUBILITY - Soluble in cold water

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposes in hot water. End products are likely to be zirconium hydroxide precipitate and chloride ion.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
18 as Zr	96	Fathead Minnow	TLm	Soft	1
240 as Zr	96	Fathead Minnow	TLm	Hard	1
15 as Zr	96	Bluegill	TLm	Soft	1
270 as Zr	96	Bluegill	TLm	Hard	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	3500	Oral	96
Rat	400	Intraperitoneal	95

ZIRCONIUM SULFATE

SYNONYMS - Disulfatozirconic Acid

COMMON SHIP OR CONTAINER SIZE - Glass Bottles, Steel Drums

M.P. 135°C loses 3 H_2O

Sp. G. - 3.22

SOLUBILITY - 525,000 ppm

PERSISTENCE

Chemical Hydrolysis, etc. - Dissociates on dissolution. Zirconium will precipitate out as hydroxide salt.

TOXICOLOGICAL

Freshwater Toxicity

ppm	hrs	Species	Parm	Cond.	Ref.
14 as Zr	96	Fathead Minnow	TLm	Soft	1
115 as Zr	96	Fathead Minnow	TLm	Hard	1

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	841-2290 as Zr	Oral	1
Rat	175	Intraperitoneal	96
Rat	1253	Oral	448

ZIRCONIUM TETRACHLORIDE

M.P. - Sublimes at 300°C

B.P. 331°C

Sp. G. - 2.80

SOLUBILITY - Decomposes

PERSISTENCE

Chemical Hydrolysis, etc. - Decomposes in water to form zirconium oxychloride and hydrochloric acid.

TOXICOLOGICAL

Freshwater Toxicity - Toxicity will be that for HCl byproduct.

Mammalian Toxicity

Species	mg/kg B. W.	Administration Route	Ref.
Rat	1688	Oral	96

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